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REPORT
OF THE
FIFTH MEETING
OF THE
AUSTRALASIAN ASSOCIATION FOR THE
ADVANCEMENT OF SCIENCE,
HELD AT
ADELAIDE, SOUTH AUSTRALIA, SEPTEMBER, 1893.

EDITED BY :
RALPH TATE, F.G.S., F.L.S.
E. H. RENNIE, M.A., D.Sc.
W. H. BRAGG, M.A.

PUBLISHED BY THE ASSOCIATION.

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1894.

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OBJECTS AND RULES OF THE ASSOCIATION.

Carried at the Christchurch Meeting in January, 1891, and Confirmed
at the Hobart Meeting, January, 1892.

OBJECTS OF THE ASSOCIATION.

The objects of the Association are to give a stronger impulse and a more systematic direction to scientific inquiry; to promote the intercourse of those who cultivate Science in different parts of the Australasian Colonies and in other countries; to obtain more general attention to the objects of Science, and a removal of any disadvantages of a public kind which may impede its progress.

RULES OF THE ASSOCIATION.

MEMBERS AND ASSOCIATES.

1. Members shall be elected by the Council; the annual subscription shall be £1, but after June 30th, 1895, members will be required to pay an entrance fee of £1 in addition.

2. The annual subscription shall be £1, due on the 1st July in each year.

3. A member may at any time become a Life Member by one payment of £10. in lieu of future annual subscriptions.

4. Members who fail to pay their subscriptions before the Annual Session of the Association cease to be members, but may rejoin by paying the entrance fee in addition to the annual subscription.

5. The Local Committee may admit any person as an Associate for the year on the payment of £1.

6. Associates are eligible to serve on the Local Reception Committee, but are not eligible to hold any other office, and they are not entitled to receive gratuitously the publications of the Association.

7. Ladies' tickets (admitting the holders to the General and Sectional Meetings, as well as the Evening Entertainments) may be obtained by full Members, on payment of 5s. for each ticket. Ladies may also become either Members or Associates on the same terms as gentlemen.

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SESSIONS.

8. The Association shall meet in Session periodically for one week or longer. The place of meeting shall be appointed by the Council two years in advance, and the arrangements for it shall be entrusted to the Local Committee.

COUNCIL.

9. There shall be a Council consisting of the following:—(1) Present and former Presidents, Vice-Presidents, Treasurers and Secretaries of the Association; and present and former Presidents, Vice-Presidents, and Secretaries of the Sections. (2) Authors of Reports or of Papers published *in extenso* in the Annual Reports of the Association.

10. The Council shall meet only during the Annual Meeting of the Association, and during that period shall be called together at least twice.

LOCAL COMMITTEES.

11. In the intervals between the Sessions of the Association its affairs shall be managed in the various colonies by Local Committees. The Local Committee of each colony shall consist of the members of Council resident in that colony.

OFFICERS.

12. The President, five Vice-Presidents (elected from amongst former Presidents), a General Treasurer, one or more General Secretaries and Local Secretaries, shall be appointed annually by the Council.

13. The Governor of the colony in which the Session is held shall be *ex officio* a Vice-President.

RECEPTION COMMITTEE.

14. The Local Committee of the colony in which the Session is to be held shall form a Reception Committee, to assist in making arrangements for the reception and entertainment of the visitors. This Committee shall have power to add to its number.

OFFICE.

15. The permanent office of the Association shall be in Sydney.

MONEY AFFAIRS OF THE ASSOCIATION.

16. The financial year shall end on the 30th June.

17. All sums received for life subscriptions and for entrance fees shall be invested in the names of three Trustees appointed by the Council, and the interest only arising from such investment shall be applied to the uses of the Association.

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18. The subscriptions shall be collected by the Local Secretary in each colony, and by him forwarded to the General Treasurer.

19. The Local Committees shall not have power to expend money without the authority of the Council, with the exception of the Local Committee of the colony in which the next ensuing Session is to be held, which shall have power to expend money collected or otherwise obtained in that colony. Such disbursements shall be audited, and the balance-sheet and the surplus funds forwarded to the General Treasurer.

20. All cheques shall be signed either by the General Treasurer and the General Secretary, or by the Local Treasurer and the Secretary of the colony in which the ensuing Session is to be held.

21. Whenever the balance in the hands of the Banker shall exceed the sum requisite for the probable or current expenses of the Association, the Council shall invest the excess in the names of the Trustees.

22. The whole of the accounts of the Association, *i.e.*, the local as well as the general accounts, shall be audited annually by two Auditors appointed by the Council; and the balance-sheet shall be submitted to the Council at its first meeting thereafter.

MONEY GRANTS.

23. Committees and individuals to whom grants of money have been entrusted are required to present to the following meeting a report of the progress which has been made, together with a statement of the sums which have been expended. Any balance shall be returned to the General Treasurer.

24. In each committee the Secretary is the only person entitled to call on the Treasurer for such portions of the sums granted as may from time to time be required.

25. In grants of money to committees, or to individuals, the Association does not contemplate the payment of personal expenses to the members or to the individual.

SECTIONS OF THE ASSOCIATION.

26. The following sections shall be constituted:—

A.—Astronomy, Mathematics and Physics.

B.—Chemistry.

C.—Geology and Mineralogy.

D.—Biology.

E.—Geography.

F.—Ethnology and Anthropology.

G.—Economic Science and Agriculture.

H.—Engineering and Architecture.

I.—Sanitary Science and Hygiene.

J.—Mental Science and Education.

SECTIONAL COMMITTEES.

27. The Presidents, Vice-Presidents, and Secretaries of the several sections shall be nominated by the Local Committee of the colony in which the next ensuing Session of the Association is to be held, and shall have power to act until their election is confirmed by the Council. From the time of their nomination, which shall take place as soon as possible after the Session of the Association, they shall be regarded as an Organising Committee, for the purpose of obtaining information upon papers likely to be submitted to the sections, and for the general furtherance of the work of the Sectional Committees. The sectional Presidents of former years shall be *ex officio* members of the Organising Committees.

28. The Sectional Committee shall have power to add to their number.

29. The Committees for the several sections shall determine the acceptance of papers before the beginning of the Session. It is therefore desirable, in order to give an opportunity to the Committees of doing justice to the several communications, that each author should prepare an abstract of his paper of a length suitable for insertion in the published transactions of the Association, and that he should send it, together with the original paper, to the Secretary of the section before which it is to be read, so that it may reach him at least a fortnight before the Session.

30. Members may communicate to the sections the papers of non-members.

31. The author of any paper is at liberty to reserve his right of property therein.

32. The Sectional Committees shall meet at 2 p.m. on the first day of the Session in the rooms of their respective sections, and prepare the programmes for their sections and forward the same to the General Secretaries for publication.

33. On the second and following days the Sectional Committees shall meet at 10 a.m.

34. No report, paper, or abstract shall be inserted in the annual volume unless it be handed to the Secretary before the conclusion of the Session.

35. The Sectional Committees shall report to the Publication Committee what papers it is thought advisable to print.

36. They shall also take into consideration any suggestions which may be offered for the advancement of Science.

RESEARCH COMMITTEES.

37. In recommending the appointment of Research Committees all members of such Committees shall be named, and one of them who has notified his willingness to accept the office shall be appointed to act as Secretary. The number of members appointed to serve on a Research Committee should be as small as is con-

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sistent with its efficient working. Individuals may be recommended to make reports.

38. All recommendations adopted by Sectional Committees shall be forwarded without delay to the Recommendation Committee; unless this is done, the recommendation cannot be considered by the Council.

39. The President of each Section shall take the chair and proceed with the business of the Section at 11 a.m. precisely. In the middle of the day an adjournment for luncheon shall be made; and at 4 p.m. the sections shall close.

40. At the close of each meeting the Sectional Secretaries shall correct, on a copy of the official journal, the lists of papers which have been read, and add to them those appointed to be read on the next day, and send the same to the General Secretaries for printing.

RECOMMENDATION COMMITTEE.

41. The Council, at its first meeting in each year, shall appoint a Committee of Recommendations to receive and consider the reports of the Research Committees appointed at the last Session, and the recommendations from Sectional Committees. The Recommendation Committee shall also report to the Council, at a subsequent meeting, the measures which they would advise to be adopted for the advancement of Science.

42. All proposals for the appointment of Research Committees and for grants of money must be sent in through the Recommendation Committee.

PUBLICATION COMMITTEE.

43. The Council shall each year elect a Publication Committee, which shall receive the recommendation of the Sectional Committees with regard to publication of papers, and decide finally upon the matter to be printed in the volume of Transactions.

ALTERATION OF RULES.

44. No alteration of the rules shall be made unless due notice of all such additions and alterations shall have been given at one Annual Meeting, and carried at a subsequent Annual Meeting of the Council.

OFFICERS AND COUNCIL, 1893.

President :

PROFESSOR RALPH TATE, F.G.S., F.L.S.

Vice-Presidents :

H. C. RUSSELL, C.M.G., B.A., F.R.S. BARON FERD. VON MUELLER, K.C.M.G.,
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ROBERT HAMILTON, K.C.B. THE RIGHT HONORABLE THE EARL OF
KINTORE, P.C., G.C.M.G.

Hon. General Treasurer :

H. C. RUSSELL, C.M.G., B.A., F.R.S.

Hon. Local Treasurer :

FREDERICK WRIGHT, Esq.

Hon. General Secretaries :

PROFESSOR LIVERSIDGE, M.A., F.R.S.

PROFESSOR RENNIE, M.A., D.Sc.

PROFESSOR BRAGG, M.A.

Hon. Secretaries for Other Colonies :

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J. SHIRLEY, B.Sc., BRISBANE.

PROFESSOR PARKER, B.Sc., F.R.S., DUNEDIN, NEW ZEALAND.

A. MORTON, F.L.S., HOBART.

Ordinary Members of Council :

The Council consists of the following:—(1) Present and former Presidents, Vice-Presidents, Treasurers, and Secretaries of the Association; and present and former Presidents, Vice-Presidents, and Secretaries of the Sections. (2) Authors of Reports or of Papers published *in extenso* in the Annual Reports of the Association.

Auditors :

R. TEECE, F.I.A.

| R. G. DALLEN.

Trustees :

H. C. RUSSELL, C.M.G., B.A., F.R.S.

R. L. J. ELLERY, F.R.S.

PROFESSOR LIVERSIDGE, M.A., F.R.S.

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D.C.L.

HON. ALLAN CAMPBELL, M.L.C.

SIR SAMUEL DAVENPORT, K.C.M.G.

REV. W. R. FLETCHER, M.A.

PROFESSOR LOWRIE, B.Sc.

A. B. MONCRIEFF, M.I.C.E.

THE PRESIDENT.

THE GENERAL SECRETARIES.

Presidents, Vice-Presidents, and Secretaries of Sections at the Adelaide Meeting, September, 1893.

	PRESIDENTS.	VICE-PRESIDENTS.	SECRETARIES.
SECTION A.—ASTRONOMY, MATHEMATICS, AND PHYSICS	H. C. Russell, C.M.G., B.A., F.R.S.	Sir Chas. Todd, K.C.M.G., M.A., F.R.S. J. J. Stuckey, M.A.	R. W. Chapman, M.A.
SECTION B.—CHEMISTRY	C. N. Hake, F.C.S., F.I.C.	T. C. Cloud, F.C.S. G. Goyder, jun., F.C.S. G. Sutherland, M.A.	T. J. Greenway, F.C.S., F.I.C.
SECTION C.—GEOLOGY AND MINERALOGY	Sir James Hector, K.C.M.G., M.D., F.R.S.	Sir Henry Ayers, K.C.M.G., F.G.S. H. Y. L. Brown, F.G.S. J. V. Parkes, F.G.S.	W. Howchin, F.G.S.
SECTION D.—BIOLOGY	C. W. de Vis, M.A.	Rev. T. Blackburn, M.A. M. Holtze, F.L.S. E. C. Stirling, C.M.G., M.D., F.R.S.	W. L. Cleland, M.B.
SECTION E.—GEOGRAPHY	A. C. McDonald, F.R.G.S.	Sir Samuel Davenport, K.C.M.G. Sir Thos. Elder, G.C.M.G. David Murray G. Goyder, C.M.G.	J. W. Jones
SECTION F.—ETHNOLOGY AND ANTHROPOLOGY	Rev. S. Ella	Rev. W. R. Fletcher, M.A. A. T. Magarey T. G. Parkhouse T. Worsnop	T. Gill
SECTION G.—ECONOMIC SCIENCE AND AGRICULTURE	H. C. L. Anderson, M.A.	Josiah Boothby, C.M.G. Professor Lowrie, B.Sc. L. H. Sholl J. H. Symon, Q.C.	E. Pariss Nesbit, Q.C.
SECTION H.—ENGINEERING AND ARCHITECTURE	R. J. Scott, A.M.I.C.E.	Hon. J. Martin, M.L.C. A. B. Moncrieff, M.I.C.E. J. H. Reed	J. T. Arrow, A.M.I.C.E.
SECTION I.—SANITARY SCIENCE AND HYGIENE	A. Mault	Hon. Allan Campbell, M.L.C. H. C. Whittell, M.D.	T. Borthwick, M.D.
SECTION J.—MENTAL SCIENCE AND EDUCATION	Professor Laurie, LL.D.	His Honor Chief Justice Way, D.C.L. E. V. Boulger, M.A., D.Lit. J. A. Hartley, B.A., B.Sc. H. P. Gill	J. A. Sunter, B.A.

GENERAL PROGRAMME FOR THE MEETING.

Monday, September 25th, 1893.

2 p.m.—Sectional Committees meet in their rooms.

8 p.m.—Lecture in the Banqueting Room, Town Hall, on “Pre-historic Man,” by E. C. STIRLING, C.M.G., M.D., F.R.S., Lecturer on Physiology, University of Adelaide, illustrated by a number of specially prepared lantern slides.

Tuesday, September 26th, 1893.

11 a.m.—General Council meets at the University.

3·30 p.m.—Reception by His Excellency the EARL OF KINTORE, P.C., G.C.M.G., in the Grounds of Government House.

7·30 p.m.—President’s Reception in the Town Hall.

8 p.m.—Inaugural Meeting and President’s Address.

Wednesday, September 27th, 1893.

10 a.m.—Sectional Committees meet.

Presidential Addresses will be delivered as follows :—

10·30 a.m.—Section A.—H. C. RUSSELL, C.M.G., B.A., F.R.S.

Section C.—SIR JAMES HECTOR, K.C.M.G., M.D.,
F.R.S.

Section I.—A. MAULT.

11·30 a.m.—Section D.—C. W. DE VIS, M.A.

Section H.—R. J. SCOTT, A.M.I.C.E.

Section J.—PROFESSOR LAURIE, LL.D.

2 p.m.—Section B.—C. N. HAKE, F.C.S., F.I.C.

Section E.—A. C. MACDONALD, F.R.G.S.

3 p.m.—Section F.—REV. S. ELLA.

Section G.—H. C. L. ANDERSON, M.A.

8 p.m.—Lecture in the Banqueting Room, Town Hall, by C. W. DE VIS, M.A., Curator of the Brisbane Museum, on “Diprotodon and its Times ”

Thursday, September 28th, 1893.

- 10 a.m.—Sectional Committees meet.
11 a.m. to 1 p.m. and 2 p.m. to 4 p.m.—Sections meet for work.
8:30 p.m.—MRS. BARR SMITH, At Home, Torrens Park, Mitcham.

Friday, September 29th, 1893.

- 10 a.m.—Sectional Committees meet.
11 a.m. to 1 p.m. and 2 p.m. to 4 p.m.—Sections meet for work.
8 p.m.—Conversazione at the University, given by His Honor the CHIEF JUSTICE, Chancellor of the University.

Saturday, September 30th, 1893.

- 10 a.m.—Sectional Committee meet.
11 a.m. to 1 p.m.—Sections meet for work.
Excursions to Hallett's Cove and the National Park.

Monday, October 2nd, 1893.

- 10 a.m.—Sectional Committees meet.
11 a.m. to 1 p.m.—Sections meet for work.
2 p.m.—General Council meets.

Tuesday, October 3rd, 1893.

Excursions to Happy Valley, Broken Hill, and Murray River.

N.B.—Luncheon and afternoon tea provided from Tuesday, September 26th, to Friday, September 29th, inclusive, in the Drill Shed, adjoining the University.

MEETING OF THE GENERAL COUNCIL.

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Tuesday, September 26th, 1893.  
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Extracts from the Minutes.

The President, Professor RALPH TATE, F.G.S., F.L.S., in the chair.

The minutes of the last meeting in Hobart were taken as read and confirmed.

Mr. A. MORTON moved—"That this Council confirm the action of the Local Committee in making all arrangements for the Adelaide meeting." He testified to the excellence of the work done by the Committee, especially by Professors Rennie and Bragg, the General Secretaries.

Professor LAURIE seconded the motion, which was carried.

On the motion of Mr. A. MAULT, seconded by Mr. C. W. DE VIS, the election of the sectional officers was confirmed.

The election of members was confirmed.

Professor LIVERSIDGE, the Permanent Secretary, apologised for the absence of Mr. H. C. Russell, the Treasurer, who was unwell. The balance-sheet had been duly audited to September 5th, and showed that the funds were in a satisfactory state. They would be able to carry on satisfactorily, and as to the publication of the volume it was trusted that the South Australian Government would make a grant for that purpose.

Professor RENNIE stated that £500 had been placed on the Estimates on condition that the money was spent in printing at the Government Printing Office.

Mr. SHIRLEY, the Local Secretary for Brisbane, said when he left that city he had been charged with the duty of proposing the election of Sir Samuel Griffith, the Chief Justice of the colony, as President. Since his arrival in Adelaide he had received a telegram from the Hon. A. Norton, stating that Sir Samuel Griffith had withdrawn, and that the Hon. A. C. Gregory, C.M.G., had consented to be nominated. He therefore moved—"That the Hon. A. C. Gregory be elected President."

Mr. DE VIS seconded the motion, which was carried.

Messrs. J. Shirley and C. W. de Vis were appointed General Local Secretaries, and the Hon. A. Norton Local Treasurer.

The following were chosen Local Secretaries:—Victoria, Mr. E. F. J. Love; New Zealand, Professor Parker; Tasmania, Mr. A. Morton; South Australia, Professors Bragg and Rennie.

Mr. SHIRLEY moved—"That the Brisbane meeting be held in 1895."

Mr. DE VIS seconded the proposal, which was carried.

Professor LIVERSIDGE moved—"That the meeting be held in January."

Mr. LOVE seconded the motion.

Mr. SIMPSON moved—"That it be a recommendation to the Local Committee at Brisbane that the meeting be held in January." It would be better to leave an opportunity for change.

Professor LAURIE seconded the amendment.

The motion was carried by a large majority.

Professor KERNOT moved—"That the meeting next following the Brisbane meeting be held in Sydney."

Professor WARREN seconded the motion, which was carried.

Sir CHARLES TODD moved, and Sir SAMUEL DAVENPORT seconded, the election of the following officers:—Recommendation Committee—The President, General Treasurer, General Secretaries, Sir James Hector, Professors Kernot, Laurie, and Lyle, Dr. Stirling, Messrs. A. Mault, A. Morton, and C. W. de Vis; Publication Committee—The President, General Secretaries, the Chief Justice, Hon. A. Campbell, Sir S. Davenport, Rev. W. R. Fletcher, Professor Lowrie, and A. B. Moncrieff; Auditors—Messrs. R. A. Dallen and R. Teece.

The motion was carried.

On the motion of Professor RENNIE, it was decided that the rule as to the payment of subscriptions every year should be suspended. He also gave notice of motion for next meeting of his desire to alter the rule so as to provide that one payment might be made for every meeting.

On the motion of Mr. A. MORTON, seconded by Professor RENNIE, it was decided to thank Professor Liversidge, who was leaving on Thursday, very heartily for his services as Permanent Hon. Secretary.

Professor LIVERSIDGE replied, and the meeting closed.

MEETING OF THE GENERAL COUNCIL.

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Monday, October 3rd, 1893.  
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Extracts from the Minutes.

The President, Professor R. TATE, presided over a good attendance.

Mr. A. C. GREGORY telegraphed—"I have to express my appreciation of the honor conferred by the appointment as the President of the Brisbane meeting of the Association."

BARON VON MUELLER telegraphed—"Gratefully appreciate sympathy expressed by the Australasian Association. I offer the best felicitations at the splendid prospects of the Adelaide meeting, which again will be of lasting prominence in the history of Australian Science."

Professor BRAGG moved—"That a committee be appointed to prepare a report on the present state of knowledge of the thermodynamics of the voltaic cell, consisting of Professor Lyle, Mr. W. H. Steele, and Mr. E. F. J. Love."

The motion was carried.

The Geological Section recommended—"That the Committee on the systematic conduct of photographic work in geological surveying be re-elected, with the addition of Mr. James Stirling and Mr. Dennant."

On the motion of Sir JAMES HECTOR, the recommendation was approved.

Sir JAMES HECTOR moved—"That the Committee of investigation upon the evidences of glacial action in Australasia be reappointed, with the addition of Messrs. George Sweet, James Stirling, and W. Howchin as Local Secretary, and that a grant of £20 be made to this Committee, to be used for labor only in investigating the glacial phenomena at Hallett's Cove."

Mr. J. STIRLING seconded the motion, which was carried.

On the motion of Sir JAMES HECTOR, seconded by Mr. A. MORTON, it was resolved—"That a committee, consisting of Messrs. A. Montgomery, W. F. Ward, R. M. Johnson, F. Kayser, and F. W. Petterd, be appointed to prepare a census of the minerals of Tasmania."

It was decided, on the motion of Mr. E. F. LOVE, to thank the Government of New Zealand for dedicating Resolution Island to the protection of native fauna.

It was decided that the Publication Committee should be instructed that such papers as had already been rejected by the Sectional Committees be not printed; and, in other cases, publication must be limited to such papers, or parts of papers, as contain original matter, or statistical matter not previously published, and are likely to maintain the reputation of the Association as a scientific body.

The recommendations of the Committee appointed to report on the protection of native fauna were—on the motion of Sir JAMES HECTOR, seconded by the Rev. W. R. FLETCHER—approved, with the exception that it was considered undesirable to appoint a Standing Committee on the subject. It was also decided to appoint the following Local Committees to report on the vernacular names of Australian birds, instead of the Committee named in the report (*see Reports of Committees*).—South and Western Australia—Dr. R. H. Perks, Messrs. A. Zietz and M. S. Clark. Tasmania—Colonel Legge, Messrs. A. Morton, and the Rev. H. Atkinson. Victoria—Mr. A. J. Campbell and Professor W. B. Spencer, with power to add one. Queensland—Messrs. C. W. de Vis and Barnard, with power to add one. New Zealand—Sir James Hector, Captain Hutton, Professor T. J. Parker, and T. F. Cheeseman. New South Wales—Messrs. A. J. North, Masters, and Thorpe; Dr. Stirling to act as General Secretary. The following were reappointed the Committee for the investigation of seismological phenomena in Australasia, with a grant of £10, namely—Sir James Hector, Sir Charles Todd, Messrs. A. B. Biggs, R. L. J. Ellery, and H. C. Russell, with Mr. Hogben as Secretary.

On the motion of the Rev. W. R. FLETCHER, it was decided—“That a committee be appointed to consider the best means of encouraging psychophysical and psychometrical investigation in Australasia, and that such committee consist of Professor Laurie, Messrs. E. F. J. Love, H. P. Gill, and J. A. Hartley, with power to add to their number.

Professor KERNOT moved—“That the best thanks of the Association be offered to the Government of South Australia for their promise to place on the Estimates a sum of £500 for the printing of the volume of proceedings, and for free postage and free telegrams in South Australia; to the telegraph departments in the other colonies for similar concessions, and to the Eastern Extension Telegraph Company and Mr. Warren for the free use of the cable to Tasmania; to His Worship the Mayor and the City Council for the use of the Town Hall and Banqueting Room; to the University Council for the use of the University Buildings; to the Board

of Governors of the Public Library for the use of rooms, and for providing free admission to the British Art Gallery, and to Mr. Lake, the manager; to His Excellency the Governor, His Honor the Chief Justice, Mr. and Mrs. Barr Smith, His Worship the Mayor, Sir Charles and Lady Todd, Mr. W. A. Horn, the Engineer-in-Chief, the President, and others, for kind hospitality extended to the members; to the Railway Commissioners for all the colonies for concessions to members travelling to Adelaide to attend the meetings; to Professor Ives for his organ performance at the inaugural meeting; to the auditors; to *The Advertiser* and the *S. A. Register* for support given to the objects of the Association, and for the full and accurate reports they have given of its proceedings; to Dr. Stirling and Mr. de Vis for their valuable lectures; and to Mrs. Bragg and the ladies associated with her for arranging decorations.

Mr. J. STIRLING considered that the Sectional Secretaries deserved full credit for what they had done.

Professor KERNOT said thanks should also be given to Professors Rennie and Bragg.

Mr. E. F. J. LOVE gave notice of motion for Brisbane to the effect that the rule for fixing the time of the meeting at 11 a.m. should be rescinded, and that sections should be allowed to choose their own time of meeting.

The Rev. W. R. FLETCHER also gave notice of motion for the division of the section "Mental Science and Education" into two sections, one for Mental Science and the other for Education.

The Council adjourned.

Table showing the number of Members present, Receipts to and Grants made, at the Annual Meetings of the Association.

DATE OF MEETING.	PLACE OF MEETING.	PRESIDENT.	SECRETARIES.	ATTENDED BY						AMOUNT RECEIVED UP TO AND DURING MEETING.	SUMS GRANTED FOR SCIENTIFIC PURPOSES.
				OLD LIFE MEMBERS.	NEW LIFE MEMBERS.	ANNUAL MEMBERS.	LADIES.	VISITORS.	TOTAL.		
				—	—	805	45	—	850	£ s. d. 858 8 0	£ s. d.
1888 { Aug. ... { Sept. ...	Sydney, New South Wales	H. C. Russell, E.A., F.R.S....	A. Liversidge, M.A., F.R.S., George Bennett, M.D., F.L.S., F.Z.S.	—	—	—	—	—	850	858 8 0	
'890—Jan. ...	Melbourne, Victoria	Baron von Mueller, K.C.M.G., F.R.S., Ph.D.	W. Baldwin Spencer, M.A.	—	—	1,081	81	—	1,162	2,081 0 0	
1891—Jan. ...	Christchurch, New Zealand	Sir James Hector, K.C.M.G., F.R.S.	F. W. Hutton, F.R.S., F.G.S., C.M.Z.S.	—	—	—	—	—	550	785 13 7	25 0 0
1892—Jan. ...	Hobart, Tasmania	His Excellency Sir Robert G. C. Hamilton, K.C.B., LL.D.	A. Morton, F.L.S.	—	—	—	—	—	600	933 16 3	
1893—Sept....	Adelaide, South Australia	Ralph Tate, F.G.S., F.L.S....	E. H. Rennie, M.A., D.Sc., W. H. Bragg, M.A.	—	—	367	121	—	488	426 2 0	30 0 0

* This sum represents the amount collected in South Australia only, and does not include the subscriptions of members outside that colony.

THE AUSTRALASIAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.



Seismological Committee.

Dr.		£ s. d.	Cr.		£ s. d.
To Amount of Grant	.....	10 0 0	By Exchange on Cheque	.....	0 1 0
			Postage of Circulars and Letters; Telegrams <i>re</i> Earthquakes, Tasmania and New Zealand		2 0 6½
			Type-writing, Copying Circulars, Reducing and Copying Returns		5 5 10
			Stationery		0 12 0
			Balance in hand		2 0 7½
		£10 0 0			£10 0 0

XXVI.

Timaru, N.Z., September 19th, 1893.

GEORGE HOGBEN, Secretary Seismological Committee.

A further grant of £10 was made to this Committee at the Adelaide meeting.

ADDITIONS TO THE LIBRARY OF THE AUSTRALASIAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Donations from January 1st, 1892, to November 15th, 1893.

[The Names of the Donors are in Italics.]

		DONORS.
ADELAIDE	Geological Survey of South Australia : Further Geological Examinations of Leigh's Creek and Hergott Districts; also, Report upon a Shale Deposit in the Encounter Bay District, by the Government Geologist : also, Papers on South Australian Lower Silurian and Mesozoic Fossils. By R. Ether- idge, jun., F.G.S., &c., 1892. Report on Country in the Neighbor- hood of Lake Eyre. By Mr. H. Y. L. Brown, 1892. Catalogue of South Australian Minerals, with the mines and other localities where found. 1893. On additional Silurian and Mesozoic Fossils from Central Australia. By R. Etheridge, jun., F.G.S.	<i>The Government Geologist</i> " " ... "
ALBANY, U.S.A.	New York State Museum of Natural History : Bulletin, Vol. I., Nos. 1 to 6, 1887-8. " " II., Nos. 7 to 10, 1889-90.	<i>The Regents</i>
BALTIMORE ..	John Hopkins University : Circulars, Vol. IX., Nos. 80-82. " " X, Nos. 83-91. " " XI., Nos. 92-100. " " XII., Nos. 101-107.	<i>The University</i> ..
BIRMINGHAM .	Birmingham Philosophical Society : Proceedings, Vol. VIII., Part I., Session 1891-2.	<i>The Society</i> ..
BONN	Naturhistorischer Vereines der Preussi- schen Rheinlande, Westfalens und des Reg.—Bezirks Osnabrück : Verhandlungen, Jahrgang, XLIX., Folge 5, Band 9, Hälfte 1, 2, 1892; Jahr- gang L., Folge 5, Band 10, Hälfte 1, 1893.	<i>The Society</i>

XXVIII.

Additions to the Library—continued.

		DONORS.
BREMEN	Naturwissenschaftlicher Verein zu Bremen. Abhandlungen, Bande xii., Heft. 1, 2, 3, 1891-3. Beilage zum, Bande xii., Heft. 1, 2, 3, 1893.	<i>The Society</i>
BRISBANE	Royal Geographical Society of Australasia (Queensland Branch): Proceedings and Transactions, Vol. ii., 1887, and Vol. iii., Part 1, 1888; Vol. vii., Part 2, 1891-2; Vol. viii., 1892-3. Natural History Society: Report of Council and President's Address, 1892.	<i>The Society</i> <i>The Society</i>
CAPE TOWN ..	South African Philosophical Society: Transactions, Vol. vi., Parts 1, 2, 1889-92.	<i>The Society</i>
FREIBURG, Baden	Naturforschende Gesellschaft: Berichte, Band iv., Heft. 1-5, 1888-9. “ “ v., “ 1-2, 1890-91. “ “ vi, “ 1-4, 1891-2.	<i>The Society</i>
GENEVA	Société Helvétique des Sciences Naturelles: Compte rendu des Travaux, 74me Session, 1891. Actes, 74me Session, 1891.	<i>The Society</i>
GÖRLITZ	Naturforschende Gesellschaft in Görlitz: Abhandlungen, Band 20, 1893.	<i>The Society</i>
HOBART	Royal Society of Tasmania: Papers and Proceedings and Report for 1891 and 1892.	<i>The Society</i>
KÖNIGSBERG ..	Königliche Physikalisch - ökonomische Gesellschaft, Schriften, Jahrgang xxxii., 1891.	<i>The Society</i> ..
LEEDS	Philosophical and Literary Society: Annual Report for 1891-2.	<i>The Society</i>
MARBURG	Gesellschaft zur Beförderung der gesammten Naturwissenschaften in Marburg: Sitzungsberichte, 1891 und 1892.	<i>The Society</i>
MELBOURNE ..	Royal Geographical Society of Australasia (Victorian Branch): Transactions, Vol. x., March, 1893.	<i>The Society</i>
MEXICO	Sociedad Científica “Antonio Alzate”: Memorias y Revista, Vol. v., Nos. 5-12, 1891-2; Vol. vi., Nos. 1-6, 9-10, 1892-3.	<i>The Society</i>

Additions to the Library—continued.

	DONORS.
MINNEAPOLIS .	Minnesota Academy of Natural Sciences : Bulletin, Vol. III., No. 2, 1891. <i>The Academy</i>
NEWCASTLE- UPON-TYNE	North of England Institute of Mining and Mechanical Engineers : Transactions, Vol. XL., 1890-91. “ “ XLI., 1891-2. <i>The Institute</i>
PARIS.....	Société d'Encouragement pour l'Industrie Nationale : Bulletin, 4 Série, Tome VII., 1892 : Tome VIII., Nos. 85 to 91, 1893. Annuaire, 1893. <i>The Society</i>
PERTH, W.A..	Census of Western Australia, April, 1891. <i>Walter A. Gale</i>
PISA	Società Toscana di Scienze Naturali : Atti—Processi Verbali, Vol. VIII., De- cember, 1892, to April, 1893. <i>The Society</i>
SALEM (MASS.)	American Association for the Advance- ment of Science : Proceedings, Fortieth Meeting, Wash- ington, D.C., 1891 Proceedings, Forty-first Meeting, Roch- ester, N.Y., 1892 <i>The Association</i>
SYDNEY	Engineering Association of New South Wales : Proceedings, Vol. VI., 1890-91 “ “ VII., 1891-2 <i>The Association</i>
TOKIO	Asiatic Society of Japan : Transactions, Vol. XVIII., Parts 1, 2, 1890 “ “ XIX., “ 1, 1891 “ “ XX., “ 1, 2, 1892-3 Transactions, Vol. XX., Supplements Nos. 1, 2, 3, 5, 1892 Imperial University of Japan : Calendar for 1890-91, 1891-2 <i>The Society</i> <i>The University</i>
TORONTO	Canadian Institute : Transactions, Vol. II., Part 2, No. 4, April, 1892 Transactions, Vol. III., Part 1, No. 5, December, 1892 Annual Archæological Report, Session 1891 An Appeal to the Canadian Institute on the Rectification of Parliament. By Sanford Fleming, C.M.G., LL.D. <i>The Institute</i>

Additions to the Library—continued.

		DONORS.
TRIESTE	Società Adriatica di Scienze Naturali : Bollettino, Vol. XIII., Parts 1, 2, 1891 “ “ XIV., 1893	<i>The Society</i>
WASHINGTON .	Philosophical Society : Bulletin, Vol. XI., 1888-91 Smithsonian Institution : Report of the Board of Regents for 1889-90 <i>Ibid.</i> , U.S. National Museum, 1889-90 U.S. Geological Survey : Mineral Resources of the United States, 1889-90	<i>The Society</i> “ <i>The Institution</i> <i>The Director</i>
<hr/>		
Author.	<i>Miscellaneous.</i>	
FEWKES, J. WALTER	American Ethnology and Archæology, Vols. II., III.	<i>Hemenway Expedition</i>
RENSCH, HANS H.	Silurfossiler og Pressede Konglomerater, I., Bergenskifrene	<i>The Author</i>

Purchased.

Hutchison's Australasian Encyclopædia. By George Collins Levey
Beeton's Dictionary of Geography. By S. O. Beeton, F.R.G.S.

ERRATA.

Page 16, twenty-two lines from top, *for* "Calamnites" *read* "Calamites."

Page 228, nine lines from top, *for* "points" *read* "prints."

Page 298, six lines from bottom, *for* f' *read* f .

Page 300, five lines from bottom—

$$\text{for } \frac{\partial v}{\partial u} \text{ read } \frac{\partial v}{\partial x} \text{ and for } \frac{\partial v}{\partial x} \text{ read } \frac{\partial v}{\partial z}$$

Page 409, twenty-one lines from top, *for* "HCHNO₃" *read* "HCl, HNO₃."

Page 421, head line, *for* "HAND" *read* "LAND."

Plate XII., lower left hand corner, *for* "NEUER" *read* "NEWER."

Plate XIV., *for* "Wanda" *read* "Wando."

INAUGURAL ADDRESS

BY

PROFESSOR RALPH TATE,

PRESIDENT,

Adelaide, Tuesday, September 26th, 1893.

MY first duty this evening is to acknowledge the high honor the association has conferred on me by electing me as its President. I accept the office with thankfulness, as it rewards me for the long years of patient striving to be thought worthy of such a distinction.

In the distant future the only antiquity that this country can ever possess is the history of the occupation by its present inhabitants. Its aboriginal people have not furnished any evidence of a past history; had it, indeed, happened that they had become extinct a quarter of a century before their discovery, the only traces of prior occupation would have been in the form of stone knives and hatchets and flint spearheads.

Interwoven with the history of the progress of discovery and occupation is that of the successive additions to our knowledge of its physical structure and its natural history. The records of botanical science and of geographical exploration have been brought up to a recent date, but the annals of the history of geological progress have not yet been consecutively placed on record. In the selection of a subject for my address I had experienced great difficulty in discriminating between personal interest and representative duty, and in choosing a

CENTURY OF GEOLOGICAL PROGRESS

for my theme I have sacrificed the former, as to please should be a part of my aim; at least it will be a reward. The labor involved in its preparation has been very heavy, though lightened by the use of Etheridge and Jack's "Bibliography of Australian Geology,"

as I have read a hundred volumes to produce a very modest pamphlet. Thus what I have done looks small when I recall the continuousness of the effort that accomplished it; but in making this estimate of results I do not overlook the effects of my exertions on myself.

The history of the progress of geology in Australia is intimately associated with that of its geographical discovery and of its advancement in scientific culture. It will constitute a chapter in the early history of modern Australia, and I venture to give some connected view of it, which, however bad it may be, is better than no view at all. Moreover, there are associated with the subject personal histories which should be recorded whilst the knowledge of them is still within our memory. And although it is my special object to depict actual culminating results, without any extended notice of the facts and events which may have led up to them, yet to a certain extent a knowledge of such facts and events is essential to their proper appreciation, and may be productive of increased interest to my audience.

Just prior to the close of the last century the controversy between the Wernerian and Huttonian schools, or those of the Vulcanists and Neptunists, relating to the origin of the crust of the earth, was at its height. The Huttonian theory, which prevailed, recognises that the strata of the present land surfaces were formed out of the waste of pre-existing continents, and that the same forces are still active. The characteristic feature of Hutton's theory is the exclusion of all causes not recognised as belonging to the present order of nature.

With the opening of the present century a new school arose, which laid the foundation of modern geology. Three men were largely concerned in this achievement—Cuvier, Lamarck, and William Smith. The two former, in France, had all the powers which great talent, education, and station could give, whilst the last was an English land surveyor without culture or influence. Cuvier laid the foundation of comparative osteology, recent and fossil; Lamarck, that of invertebrate palæontology; whilst Smith established the fundamental principles of stratigraphical palæontology, viz., the superposition of stratified rocks and the succession of life in time.

“The growing importance of the natural history of organic remains may be pointed out,” writes Sir Charles Lyell, “as the characteristic feature of the progress of geological science during the present century.”

The earliest geological observations relating to Australia antedate by only a few years the beginning of this century, so that the history of our progress in geology is concurrent with that of modern geology, and it affords grand illustrations of the methods of application of the laws as they were successively evolved in the European schools to an area so distantly removed from that which gave them birth. Thus our history begins at a most fortunate period. No prejudices or scholastic disputations have retarded our progress, for those who have aided in the work were disciples in the modern school of geology. And though, on a retrospective glance, we may hesitate to attach any high value to the labors of pioneer geologists, yet we should not forget that our horizon is much vaster than theirs, and that the extension of it is partly due to their labors; and though it may be true that if the geological progress of the first half of this century were quite ignored we should not suffer any great loss (as I believe that nearly all the areas explored at the earlier period have been re-examined in later times by men more carefully trained than was previously possible), nevertheless the gradual accumulation of data supplies us with a history, and makes us better acquainted with the causes that at certain times made that progress slow or even retarded it.

For the first three or four decades of this century our geological knowledge was almost entirely the outcome of maritime surveys, whilst in later years it has been largely supplemented by inland exploration. Thus, for a half century or so the geological progress is part of the history of topographical discovery, and this explains why our earlier geological information is inseparable from the achievements of such renowned geographers as Flinders, Baudin, King, Sturt, Mitchell, Stokes, Wilkes, Leichhardt, A. C. Gregory, and others.

The subsequent history of our geological progress commences with the establishment of systematic geological surveys in New South Wales and Victoria, which afterwards led to their extension to the other provincial areas. Almost simultaneously universities were founded at Melbourne and Sydney. Thus, whilst the surveys dealt with geology more in its industrial applications, the universities upheld its value on purely scientific grounds. By these agencies a large interest was awakened in the science, and many whose zeal had been latent were added to the ranks of geological investigators. Much of our knowledge gained in these various ways is expressed on the Geological Map of Australia, published by the Victorian Government in 1887. The several steps by which this map

has been built up I will endeavor to make known to you ; and though my geological reminiscences do not extend far back, yet they embrace some of the most important discoveries made on this continent.

Though the discovery of Australia may date back to the middle of the sixteenth century, yet it continued a *terra incognita*, at least from a scientific point of view, until Cook, the Columbus of the South, began, in 1770, the present phase of scientific expeditions ; and though geology reaped no gain, yet in botany was laid the foundation of a knowledge of that marvellous and peculiar flora of Australia through the labors of Banks and Solander, the companions of Cook. Banks had collected at Sydney a clay which was then considered a distinct mineral, and had been called *Sydneyite* or *Sydneya*. Its real nature was made known by Hatchett* in 1798, and it was subsequently examined on the spot by Depuch and Bailly† with similar results.

LA PEROUSE, in a voyage round the world, anchored off Norfolk Island in January, 1788, and described it as if surrounded by a wall formed by lava that had flowed from the summit of the mountain. The absence of any geological reference to Botany Bay, which was next visited, may be attributed to the loss by assassination at Maoua, in the South Sea Islands, of that accomplished mineralogist La Manon, one of the naturalists to the expedition, on whom devolved the geological observations.

VANCOUVER,‡ who discovered King George Sound in 1791, describes the summit of Bald Head as covered with a coral structure, amongst which are many sea shells, and argues a modern date of elevation. However faulty the interpretation of the nature of the data may be, yet the deduction is sound, and it may be claimed as the first recorded geological observation for Australia, made one hundred and two and a half years ago.

D'ENTRECASTEUX, in 1792-93, when in search of the ill-fated La Perouse, examined the coastline from Cape Leuwin to Nuyt's Archipelago, and visited Tasmania ; and although no geological observations seem to have been made on the continent, yet a rich harvest fell to the lot of La Billardiere, the botanist attached to the expedition, who discovered coal near South Cape, and stated that limestone existed on Bruni Island.

COAL was discovered in New South Wales in 1797§, first to the south of Sydney, and in the same year on the banks of the River

* Phil. Trans. Roy. Soc., London.

+ Pers. n. Voy. Terres Australes, i., p. 443, 1807.

‡ Voyage South Seas, vol. i., p. 77. 1801.

§ Flinders, Voy. Terra Australis, vol. i., pp. civ-cv.; Collins, Account of New South Wales, 1798, p. 617.

Hunter, where Newcastle now stands. After its discovery little exploitation was done for the first thirty or forty years; the first export was in 1801, and in 1828 it reached 974 tons. The Government mine at Newcastle became in 1830 the property of the Australian Agricultural Company, which had the exclusive right to mine for thirty-one years, but this monopoly was mutually terminated in 1847. The estimated value of the output of coal up to 1835 was £43,504; in the next ten years it was £129,112, while in the next decennial period it attained to £6,766,970, as a consequence of the discovery of gold, but for 1855 to 1865 it rose to £16,001,504, this vast increase being due to the fact that gold was produced during the whole decade*. The coalfield of New South Wales embraces an area of 15,419 square miles, and the quantity of future available coal within a depth of 4,000ft., from seams over 2½ft., allowing for loss in working, is estimated by Geological Surveyor C Wilkinson† at 78,198,200,000 tons.

FLINDERS and BASS‡, jointly and separately, between the years 1797 and 1798, had explored the coastline southward from Sydney, reaching as far west as Western Port, and they embraced in their voyage the circumnavigation of Tasmania. They described the more prominent rock phenomena, such as the basalts of the Illawarra Coast, the perpendicular slates of the Furneaux Islands and their penetration by granite, and the lofty mass of hard granites of Wilson Promontory.

In 1801 Flinders was commissioned to complete the examination and survey of New Holland. In the list of scientific officers appears the name of Robert Brown. To the 1,300 ascertained plants, chiefly collected by Banks and Solander, he added nearly 3,000 species by his personal labors, and eventually there were available to the author of the "*Prodromus Floræ Novæ Hollandiæ*" about 6,000 species. The coastline of Australia was traced with care as far as the tropics. Flinders paid much attention to physiographic features, whilst Brown collected rock specimens. The narrative by Flinders§ is interspersed with occasional references to rock structure, and he particularly notes the prevalence of granite as a subter-structure, with a calcareous stone for a cover, throughout the southern coastline. Mr. Brown ascended the high peak in the Flinders Range which bears his name, and found the stone of this craggy mountain ridge to be slaty. The rock specimens collected

* Abstracted from *Mineral Products of New South Wales*, by Harrie Wood, 1887, pp. 4, 5.

† Aust. Assoc. Adv. Sc., vol. II., p. 463. 1890. ‡ *Voyage Terra Australis*. 1814. § *Id.*

on this survey were reported on by Dr. Fitton* in 1825, but nothing was done beyond their mere enumeration and the indication of their agreement with those of the same denomination from other parts of the world, no attempt having been made to chronologically arrange them. Others collected by Brown during his sojourn in New South Wales were reported on by Dean Buckland in 1821, hereafter referred to.

Contemporaneous with the marine survey by Flinders was that by the French, under Baudin, who sailed along the outside of the islands which fringe a great extent of the north-west and south coasts, but who seldom visited any part of the mainland. The scientific equipment of this expedition is unrivalled in the annals of Australian exploration. To Depuch and Bailly were entrusted the mineralogical and geological researches. The former left the ship at Sydney to return to Europe, but he died at Mauritius, and his manuscripts, which he had taken with him, and which were to serve for a geological history of New Holland, were irrecoverably lost.

PERON was the senior zoologist and the author of the narrative of the expedition†, the first volume of which was published in 1807; but the author died in 1810, before the appearance of the second volume in 1816, which was edited by his companion, Freycinet. His account of the physiography and geology of the places visited is not only graphic, but rich in details; he closely investigated the nature and origin of the Æolian calciferous sandstones, and fully recognised their relationship to the blown sand of the dunes. This dominant feature of the southern shores of Australia is stated by him to be reproduced on the west and north-west coast. The entombed calcified shapes of branches and stems of trees were correctly recognised, though Vancouver and Flinders had erroneously considered them as coral reefs. He rightly referred the fundamental rocks of Kangaroo and King Islands to different kinds of primitive schists, and the superimposed fossiliferous limestone at the former place was correctly observed, though not attributed to any particular epoch. The occurrence of corals and marine shells of recent appearance at considerable elevations on the coast was justly regarded by him as demonstrating the "former abode of the sea" above the land, and very naturally suggested an inquiry as to the nature of the revolutions to which this change of situation is to be ascribed. The diorite of Depuch Island is described as

* Proc. Geol. Soc., London.

† Voyage de Découverte aux Terres Australes Historique, 2 vols.

columnar basalt, and the occurrence of granite and primitive rocks is mentioned as forming the basis of the more jutting points and masses on the coastline and islands.

BAILLY described the geology about Sydney as consisting first of the Sydney sandstone, which is noted as extending from the seaboard to the escarpment of the Blue Mountains; secondly, about Paramatta, of bituminous shales, full of plant impressions, chiefly ferns, disposed in horizontal layers alternating with sandstones and conglomerates. He ventured to predict the occurrence of coal similar to that to the north and south of Sydney at no great depth. He inferred the existence of a granitic or primitive base somewhere within the basin of the Hawkesbury River from the presence of pebbles of these rocks in the bed of the river at Richmond Hill. He discovered kerosene shale at the foot of the Blue Mountains, afterwards, but elsewhere, observed by P. Cunningham in 1827, and rediscovered by Strzelecki in 1845.

Few geologists have been more in advance of the age in which they lived, or have suffered so long an undeserved oblivion, as Peron.

After the termination of the survey by Flinders, through the loss of his ship and subsequent detention by the French, in the which France was the first to debase as she was the first to promulgate that principal axiom of international law, "*Causa scientiarum, causa populorum*," twelve years elapsed before England's attention was diverted from the battlefield to geographic discoveries in Australia, and CAPTAIN KING was appointed to complete the coast surveys left unfinished by Flinders, which occupied him from 1818 to 1822. KING could spare but little time to land, and, with few exceptions, merely traced the coast. The paucity of geological information is thus accounted for, and the few references are merely lithological. Owing to Captain King's own love for natural history, and the encouragement he consequently gave to the botanist, Allan Cunningham, who accompanied him, his surveys were the means of adding very largely to our knowledge of the vegetable and animal life of Australia, especially of the tropical parts. All the geological observations he was able to make, as well as those by Robert Brown when with Flinders, were excellently digested by Dr. Fitton, in a general *résumé* appended to an account of the voyage.*

OXLEY, John, Surveyor-General, to whom we owe the earliest topographical map of New South Wales, took charge, in 1817, of

* Narrative of a Survey of the Intertropical and Western Coasts of Australia, 2 vols. 1826

an expedition to ascertain the character of the western interior, a practicable route across the Blue Mountains having been opened in 1815. He traced the Lachlan down to longitude 144°, and completed the discovery of the Blue Mountains, which constitute the prominent physiographic feature of New South Wales. In 1818 he traced the Macquarie River to its junction with the Darling. In the volume of his narrative* are brief references to the occurrence of different rocks, amongst which the more noteworthy are coal at Port Macquarie harbor, coal indications at the head of the Macleay River, and limestone at Limestone Creek on the Lachlan, and at Wellington Valley on the Macquarie, "which is the first that has hitherto been discovered in Australia." The geological specimens which were collected during the two expeditions were reported on by Dean Buckland† as affording indications of primitive rocks (granite, mica slate, clay slate, and serpentine), trap, and limestone (resembling the "transition limestone" of England); as also those gathered by Robert Brown on the Hunter River, which are described as coal and shale with plant impressions, and the author states that there is an analogy between the Coal Formation of the Hunter River and that of England, whilst certain fossiliferous rocks from Hobart are described as nearly, if not identical with those of the Mountain Limestone of England and Ireland. [This is the first application of palæontology to the stratigraphical chronology of the Australian rocks, and a successful one, as the positions assigned by Buckland to the two formations are substantially those accepted by the local geologists of to-day.]

SCOTT, Rev. Archdeacon‡, refers the strata of the Newcastle coalfield to the "coal formation" and the limestone as resembling in the character of its organic remains the "mountain limestone" of England, and thus independently arrived at the same conclusions as Buckland.

BERRY, Alexander§, describes the lithological sequence of the strata of the Hunter River coalfield as traced by him for nine miles south from Hunter River. The vegetable impressions are referred to, and he thought he had recognised the leaf of the living *Zamia spiralis*. He confounded the Carboniferous sandstone with that forming the Blue Mountains, though he recognised the intrusive nature and overlying position of the trap rocks. He records a sandstone lying on indurated clay slate, at Shoalhaven; and at

* Two Expeditions into the Interior of New South Wales (1820).

+ Geological Trans., vol. v., p. 480. 1821.

‡ Annals of Philosophy, June 24th. 1824. Bull. des Sciences Nat., 1826, p. 285.

§ Geology of part of New South Wales, 1822, in Field's Geographical Memoirs. 1825.

twenty miles up the river, sandstone with included fragments of older rocks; at Jervis Bay and Bowen Island, horizontal sandstone; at River Clyde, coarse argillaceous schist, like greywacke in appearance; at Bateman Bay, clay slate in vertical position. [This author added, thus, a number of valuable facts to the geology of New South Wales, and had they been successfully systematised the contribution would have been a great advance to our knowledge of stratigraphical geology.]

CUNNINGHAM, Allen*, Botanical Collector for Kew Gardens, journeyed in 1823 from Bathurst to Liverpool Plains, and thence to Darling Downs, and though the special object was botanical, yet geography benefited. Several passing references are made to the rocks encountered, and he describes the physiographic features and the leading rock structure of the Blue Mountains. He discovered the Ipswich coal formation on the Brisbane River in 1828. His collected geological observations made on these and other occasions were communicated to the Geological Society of London.†

OXLEY, John‡, in 1823 discovered the navigable river Brisbane, and in his official report are incidental references to geological features, such as those relating to Facing Island (which is uncolored on the Geological Map of Queensland, 1893), which protects Port Curtis—"There are many indications of mineral substance; some seemed to contain copper and tin."

UNIACKE, in his narrative of Oxley's expedition of 1823§, describes the basal part of Small Island, off Point Danger, as "of volcanic origin, and the superincumbent rocks to be basaltic," and these are compared with the Giant's Causeway in the north of Ireland. The right bank of the River Boyne, Port Curtis, is stated to be composed of fine slate, and the left of close-grained granite. (This is in agreement with the geological survey map of 1893—the slate rocks belonging to the Gympie Formation).

LESSON, the naturalist to the French surveying ship, *La Coquille*, and author of the history of the voyage during the years 1822-5, describes the geological features about Port Jackson as constituted of—

1. Granites, quartziferous syenites, and pegmatites.
2. Stratified lignites, which are mined at Mount York at an elevation of 1,000ft. above sea level.

* Field's Geographical Memoirs. 1825. + Proc. Geol. Soc., vol. II., p. 109. 1834.

‡ Expedition to Moreton Bay in Field's Geogr. Mem. 1825.

§ Field's Geogr. Memoirs. 1825.

3. Ferruginous sandstone, which covers not only a vast extent of country near the coast, but forms the plateau of the Blue Mountains. This stratum, because of its superior position to the foregoing, appertains to the Tertiary system.

This arrangement is a great advance on prior contributions, as it establishes a definite successional order of deposits; and for the first time, though this was foreshadowed by his countryman Bailly, the superposition of the Sydney sandstone (No. 3) on the Coal Measures (No. 2) and of these on the granites (No. 1) is recognised.

CUNNINGHAM, P.*, traces the Coal Measures from Port Stephens to Botany Bay and interiorly about 100 miles along the Hunter River, and notes the occurrence of plant remains and upright trunks of trees in the beds; various rocks are named, and the occurrence of limestone at Bathurst (previously observed by Oxley) is mentioned as being the nearest to Sydney.

Up to this date no described fossil had been referred to as occurring in Australian deposits, and it was not till 1828 that Alex. BRONGNIART† described *Glossopteris Browniana* and *Phyllothea Australis* from the Newcastle Coal Measures.

SCOTT, Rev. Archdeacon‡, describes the coastal calciferous sandstone about Swan River, and the Darling Range, as consisting of greenstone and syenite, and to the southward of clay slate.

CUNNINGHAM, P.§, describes the leading lithological features of the country about Liverpool Plains; he mentions a coralliferous limestone, as well as other fossiliferous strata, but makes no attempt to make out the order of superposition or the equivalents of the strata.

STURT||, during 1828-1831, corrected Oxley by proving that the superfluous waters of the western slope of the Blue Mountains were drained by the River Murray, and thus achieved a most important discovery. In 1829 he followed the Murrumbidgee to the Murray, and thence to Lake Alexandrina. On his passage down the Murray he arrived at Overland Corner, and noted there the sudden change from cliffs of sand and clay to fossiliferous limestone, which continued uninterruptedly to Lake Alexandrina. Sturt referred examples of the fossil *mollusca*, *echinoids*, and *polyzoa* to species of the Eocene of England, Paris, and Westphalia, and thus established by similarity of organic remains an old Tertiary formation

* Two Years in New South Wales, 1827, vol. II., pp. 1-12.

† Histoire des Végétaux Fossiles, 2 vols., 1828, I. p. 222.

‡ Proc. Geol. Soc., vol. I., 1831, p. 320.

§ Proc. Geol. Soc., vol. I., 1831, pp. 225-226.

|| Two Expeditions into the Interior of Southern Australia. 1833.

in Australia; and though it has subsequently been shown that all of Sturt's identifications were wrong, yet, as most of the species are near allies to those to which he referred them, it is not surprising that after all Sturt was right in his correlation. Sturt refers also to a compact limestone, containing corals, occurring in a range sixteen miles due north of Bathurst, of an unassigned age; also independently observed by P. Cunningham at about the same time.

MITCHELL, Major (afterwards Sir Thomas)*.—In 1832 he penetrated north and reached the River Darling, in lat. 29° ; his western limit, in 1838, was the junction of the Rivers Bogan and Darling; and the southern, in 1836, was Portland Bay. He corroborated all the geographical features and positions previously ascertained by Oxley and Sturt, and determined many new discoveries, especially that of Australia Felix or the mid and western portions of Victoria.

The chief geological observations recorded by Mitchell are :—

1. That the higher ground about the sources of the tributaries of the Murrumbidgee is composed of granite, on the flanks of which rests a fossiliferous limestone "much resembling the Carboniferous of Europe," and that there is another limestone about Limestone Plains containing corals, belonging to the genus *Favosites*, and crinoids.
2. That in Victoria, north of the Dividing Range, granites and syenites are to be found, and clay slate on the River Campaspe.
3. That the lower part of the Glenelg River and the country stretching to Portland Bay is occupied with a fossiliferous Tertiary formation, which is frequently interrupted by trap and vesicular lava; hills of lava often occur, and one, at least, Mount Napier, is described as still exhibiting a perfect circular crater.

The palæontological collections which were made during Mitchell's three expeditions were deposited in the British Museum, and reported on by specialists. The results appended to Mitchell's work demonstrated the presence of representatives of the following life epochs :—

Carboniferous—Various species of mollusca, from the valley of the Hunter River, were described and figured by J. D. C. Sowerby, but no conclusions as to age or stratigraphical position were attempted by him. Mitchell records spirifers in the sandstone at

* Three Expeditions into the Interior of East Australia. 1838.

Mount Wingen, and notes that the fossil vegetation consisted chiefly of *Glossopteris Browniana*.

Mesozoic.—The collection included also a portion of the guard of a *Belemnite*, obtained near Mount Abundance; its occurrence is noted on Mitchell's chart, though not referred to in the letter-press. This is the first secondary fossil recorded for Australia, though it was not till 1880 that it was brought to scientific notice by Mr. Robert Etheridge, jun.* It probably belongs to the Cretaceous species, *Belemnites Australis*, Phillips.

Diprotodon Period.—The ossiferous caves of the Wellington Valley and at Burree were discovered by Mitchell in 1830, and an account of the survey of them was published in 1831.† In 1835 more extended researches were undertaken, and the particulars respecting the animal remains then found were supplied by Owen (afterwards Sir Richard), who demonstrated that the existing marsupial fauna was preceded in the same area in later Tertiary times by one in many respects similar, yet differing for the most part specifically and to some extent generically, presenting forms which are colossal in comparison with the largest modern representatives. Such are *Diprotodon* and *Nototherium*. This early work of Owen's was only the commencement of those investigations which culminated in that monument of marvellous industry and talent, the "Fossil Mammals of Australia."

DARWIN, Charles, was naturalist to the surveying ship *The Beagle* on her second voyage, 1832-36. *The Beagle*, on her homeward passage, called at Sydney and King George Sound. The geological observations relating to those places are brief, and to a large extent had been anticipated by Mitchell in respect of the first, and by Peron in respect of the second, while, as regards King George Sound, Darwin corrected some of the erroneous observations recorded by Vancouver and Flinders. Lonsdale describes some Australian Carboniferous Polyzoa, and Sowerby some Spiriferidæ‡; and we have thus another instance of the early application of palæontology to the determination of the correlative age of stratified deposits.

GREY, Lieut. (now Sir George)§ was commissioned to explore the coastline between Prince Regent River and Swan River. Towards the end of 1837 he landed at Hanover Bay, and found the shore fringed with bold inaccessible hills and bluff headlands, as

* Proc. Roy. Soc., Tasmania, for 1879, p. 18.

+ Proc. Geol. Soc., vol. i, p. 321.

‡ Darwin's Volcanic Islands. 1844.

§ Journals of Two Expeditions in N.W. and W. Australia, 2 vols. 1841.

described by King. Under great difficulties he ascended the elevated tableland with its deep ravines and gorges, which he describes as consisting of horizontally-bedded sandstones crowned by basaltic elevations. In 1839, he was shipwrecked in Gantheaume Bay, and his party was forced to make an overland journey to Perth, in the course of which he discovered the Murchison and other rivers, and the Carboniferous rocks in the Victoria Range.

STOKES, Commander.—Captain Wickham was commissioned in 1837 to *The Beagle's* third voyage. Under him some of the most important objects of the voyage were achieved, but in consequence of his retirement in March, 1841, owing to ill-health, the command devolved on Captain Stokes, who is the author of the narrative of the six years' voyage.* The objects of the survey did not permit of any connected observations of the geological structure of the islands or coast, and though the author disclaims any pretention to be versed in geological science, yet some of his recorded observations have the merit of discoveries, which have stood the test of critical investigation. The Æolian calciferous sandstone of Swan River is described, and he mentions that the most remarkable feature is the absence or scantiness of the secondary and transition rocks; all the Tertiary appears to be of the newest kind, and to be in juxtaposition with the Primary. The Darling Range is stated to be granitic, and slate of a primitive character is mentioned as occurring at the Canning River.

The Carbonaceous series of rocks chiefly to be met with at Western Port are considered analogous to those of the Carboniferous formation, and the occurrence of coal in the same series at Cape Patterson is announced.

The escarpment of the tableland of Arnheim Land is described as constituted of horizontally-bedded sandstone overlying slaty rock. A somewhat similar arrangement is noticed at Tale Head and Fort Hill, Port Darwin, and the covering fine-grained sandstone, the stratigraphical position of which was first observed by Stokes, has lately acquired considerable importance by the discovery of radiolarians within its mass.† Fossils were collected from a cliff named Fossil Head, near the mouth of the Victoria River, but they were subsequently lost or destroyed.

STRZELECKI, Count‡.—To this highly accomplished scientist we are greatly indebted for his arduous and gratuitous researches

* Discoveries in Australia, 1837-1843, 2 vols. 1846.

† Quart. Journ. Geol. Soc., vol. XLIV., p. 221. 1893.

‡ Physical Description of New South Wales, &c. 1845.

and labors in the field of Australian geology, the outcome of five years' travel, commencing from his traverse of Gippsland in 1840, and embracing the survey of 7,000 miles. The rocks of New South Wales he arranges in an ascending successional series, and in this first attempt to construct a table of the stratified deposits of New South Wales he laid the foundation of stratigraphical geology in Australia. His summary is as follows:—First epoch—(a) Irruptive crystalline rocks, constituting the axis of elevation, as granite, syenite, eurite, &c. (b) Stratified crystalline rocks as mica slate. Second epoch—Characterised by arenaceous, calcareous, and argillaceous deposits, which rest on the former, and in Australia contain the first record of organic life; among the stratified masses are intruded porphyrites, basalts, &c. The greater part of the Palæozoic rocks in Australia examined by Strzelecki is the equivalent of the “Carboniferous,” though others (particularly about Yass Plains) are anterior, and may probably be considered the equivalent of the Devonian System of Europe. [This is the first recognition of a fossiliferous group older than Carboniferous.] Third epoch—Includes the coal-series of the Newcastle basin. Fourth epoch—Embraces gravel beds, elevated beaches, osseous breccias; alluvial deposits about Port Western are included, also the variegated sandstones of the tableland of the Blue Mountains; “above the last no other formation has yet been found, and they constitute the highest beds in the geological series.” In this epoch are included deposits now known to be of older Tertiary age, as the Eocene at Port Fairy and Table Cape, and the Miocene at Lake King, Gippsland, “which contain *Ostrea* and *Anomia* different from the existing species.” Strzelecki's volume is accompanied by a map, in which the areas occupied by each epoch are indicated by colors, and this is the first attempt at geological mapping in Australia. The Palæozoic corals and polyzoa are described by Lonsdale, the plant remains and Palæozoic mollusca by Morris, and the Pliocene mollusca by G. B. Sowerby. Morris pointed out that the facies of the coal flora was remarkably distinguished from that of Europe and to have strong points of similarity with that of Northern India and of the Yorkshire Oolites. The doubt had thus early been expressed as to the possibility of the Hunter River coals belonging to the Jurassic system.

LEICHHARDT, Dr. Ludwig.—In 1844 this lamented traveller started on his adventurous journey from Moreton Bay to Port Essington, a distance of 3,000 miles. The expedition originated in

private enterprise, but was promoted by public subscription, and the Treasury of New South Wales voted £1,000 to be distributed among the members on their return, which sum was increased by public subscription to £2,519. The narrative of Dr. Leichhardt* contains as much botany as geography, and is by far the fullest published account of the tropical vegetation of the north and north-east tracts and adjacent interior parts of Australia that we possess. The accompanying maps and illustrations supply important information respecting the physiographic and geologic features. Necessity compelled him to abandon one portion after another of his collections, so that the opportunity of determining the age of the various deposits encountered from the nature of their fossil contents was lost. This is much to be regretted, because for long years this line of country was geologically known only through Leichhardt's memoranda, which contain for some portions the only information extant. He mentions the existence of coal on the Mackenzie and Bowen Rivers, and sandstones with plant remains on the Dawson, Comet, and Isaacs Rivers, and in other parts of Northern Queensland, though the geological horizon is not recognised. He describes the metamorphic and basaltic areas, and discovered the fossiliferous limestone on the Burdekin River which the Rev. W. B. Clarke referred to the Upper Silurian, but which is now classed as Middle Devonian. The tableland of North Australia, which reaches to near the coast, is graphically described, and its elevation overlooking the Alligator Rivers is given at 1,800ft., reduced by subsequent trigonometrical measure to 670ft. Hereabouts he found evidences of a fossiliferous rock.

DANA, Professor James D., was naturalist to the United States exploring expedition during the years 1838-1842, under the command of Charles Wilkes. Sydney was visited in 1839-40, but as the geology of the expedition was not published till 1849 Dana's observations were to some extent anticipated by the published writings of Strzelecki, Morris, Lonsdale, and McCoy. Nevertheless the credit must remain to Dana of having laid the foundation of the classification of the great Carboniferous development in New South Wales, both in respect of its palæontology and stratigraphy. Dana was, however, acquainted with the palæontological works of the forenamed authors, and incorporated the results in his own. He describes the geology within a radius of sixty miles of Port Jackson under three headings:—(1) Sandstone above the Coal, or the "Sydney Sandstone"; (2) The Coal Formation; and (3) Argil-

* Journal of an Overland Expedition in Australia, &c., 1844-1845. 1847.

laceous Sandstone below the Coal. The characters proper to each are briefly summarised as follows:—

Sydney Sandstone.—Thickness, 1,400ft.; the lithological character, cross-bedding, occasional concentric structure, horizontal position or dip never exceeding 12° , and the joints in two directions at right angles are noted, as also the paucity of organic remains, there being no animals, but few vegetable impressions and thin seams of bituminous coal: imbedded minerals almost absent.

Coal Formation.—(1) Of the Hunter River Valley: the section at Nobby Island and Telegraph Hill is described as containing five distinct seams of bituminous coal, and stratigraphical and lithological details are given; faults and basaltic dykes intersecting the strata are recognised. (2) In the Illawarra district: the section at Bulli Cliffs is described and the vegetable impressions are observed to be less plentiful than in the Hunter Basin, the extension of the formation is also traced as far south as Wollongong and Dapto. Except one species of fish, the fossils of the coal formation consist of plants, the prevalent species being small ferns and equisetaceous forms and the remains of conifers allied to recent pines, but *Glossopieris Browniana* constitutes four-fifths of all plant remains. The absence of *Calaminites*, *Sigillaria*, and *Lepidodendron* is noted.

Sandstone Strata below the Coal.—It is noted that the gradual transition seen between the Coal Formation and the Sydney Sandstone is traceable between it and the underlying sandstone, which is called “sub-carboniferous.” This formation occurs from Wollongong southward to Shoalhaven River; and in the Hunter Valley at Harpur’s Hill, Glendon, and Mount Wingen. He describes its lithological characters (in general a greenish compact sandstone), stratification, dip, joints, faults, &c. The fossils of the “sub-carboniferous” are chiefly mollusca, corals being few and plant remains scanty; eighty-six species are described and figured.

Dana agrees with Morris as to the “Carboniferous character of the animal remains in the Coal Formation and subjacent sandstone,” and that the plant remains are of more uncertain chronology, as they differ from those of the American and European Carboniferous beds and present close relation to those of the Oolite.

STURT, Captain Charles*, in 1844, under the authority of the Imperial Government, pushed into the central parts of

* Narrative of an Expedition into Central Australia during 1844-46. 1849.

Australia. From the River Darling, at what is now Menindie, he reached the Barrier and Grey Ranges, and became entangled in the delta-like ramifications of the River Cooper; thence he penetrated in a north-west direction into the sand-dune country to the north-east of Lake Eyre, and thus missed the object of his ardent search. Sturt describes the general structure of the Barrier Range as of slates, gneiss, and other metamorphic rocks, and notes the prevalence of iron ores. He describes what is evidently the ironstone outcrop of a massive mineral lode, and though I cannot identify the locality, yet it is not at all improbable that one of the silver lodes of the Barrier (if not Broken Hill itself) is here referred to; in the same connection that prominent landmark, Piesse's Knob, is indicated. The Grey Range, he says, resembles the Barrier Range, and has the same bearing; he compares them with the Mount Lofty chain, and implies that they constitute one formation. Between the Grey Range, and near to Strzelecki Creek, he observed "some fossil limestone cropping out of the ground in several places." The most noteworthy observations recorded by Sturt are those relating to the physical character of the interior of Australia, which will be considered hereafter. A tribute is due to Sturt's scientific merit and sagacity, and I would add my mite to the general testimony of admiration for that learned traveller. He stands pre-eminent among land explorers for the accuracy of his observations, evincing the most patient and thoughtful investigation, for the great power of generalisation which throws a charm over all his narratives, and for his highly philosophical deductions. Sturt never received that honor in his lifetime which was his due; and much of his geological work and speculations have either been overlooked or ignored, because it was thought (geology being then in a not very advanced state) that he was not a very experienced geologist.

JUKES, J. Beete, who in 1839-40 held the office of Geological Surveyor for Newfoundland, was appointed naturalist to H.M.S. *Fly*, commissioned to survey the northern part of the Barrier Reef. He wrote the "Narrative of the Voyage" (1847), which embraced the years 1842-46. In this work the author does not occupy himself with geological matters, which are dealt with in other publications* and incorporated in an independent work, entitled "A Sketch of the Physical Structure of Australia" (1850). In this later work the author gives a connected outline of the geology of

(1) Brit. Assoc. Adv. for Science, 1846; Quart. Journ. Geol. Soc., vol. III., p. 241, 1847; *Id.*, vol. IV., p. 142, 1848.

Australia, so far as it was known to him. The great merit of this attempt to exhibit approximately the principal features of this continent is that of piecing together the isolated observations of previous authors into a connected outline. This, because of his personal knowledge of considerable portions of the coastline of Australia, he was of all others the best able to do successfully. The result is a general but distinct notion of the geological structure of Australia, which is further illustrated by a geologically-colored map, the first containing so broad a survey. The author added nothing to our previous knowledge, but systematised what was known, and the speculations and generalisations which he ventured to put forward have for the most part proved correct. Some of the most valuable contributions of later authors will be found to have been foreshadowed, or even clearly noted by Jukes, whilst some actual discoveries were anticipated by him. His map shows—(1) Alluvial deposits, (2) coral reefs, (3) Tertiary rocks, (4) unknown, probable Tertiary, (5) Palæozoic rocks, (6) unknown, probable Palæozoic, (7) metamorphic rocks, (8) modern igneous rocks, (9) old igneous rocks, (10) granite, pegmatite, &c. The members of the coal series of New South Wales are given substantially as those enumerated by Dana (whose work Jukes had evidently not then seen), but the Wianamatta shales are specially mentioned as separable from the underlying Sydney sandstone. The coal-bearing beds at Western Port and to the west of Geelong are regarded as Palæozoic. The rocks about Port Phillip are referred to a Palæozoic age, the fossiliferous beds at Brighton to a Tertiary formation, and the volcanic rocks about Melbourne to more recent sub-aerial lavas, whilst the lowlands of Gippsland are considered to be occupied by Tertiary deposits. The rocks of the Mount Lofty chain, in South Australia, are classed as metamorphic. The Tertiary of the Lower Murray and the Glenelg River he considers to be part of a widespread formation, embracing Adelaide and Port Phillip, but to be of a very modern date, whilst that remarkable mural line of sea cliffs extending westward from the head of the Great Australian Bight is conjectured to be Tertiary, and to stretch far into the interior, and in all probability to join on to Sturt's great central desert of sand and ironstone (a conception of Sturt's).

MACGILLIVRAY, John.—The last of the maritime surveys under Imperial direction which concerned Australia was that conducted by Captain Owen Stanley, of H.M.S. *Rattlesnake*; it is noteworthy from the high scientific attainments of its officers. The Commander, who was the only son of Dean Stanley, himself an eminent

ornithologist, took a keen interest in natural history. He died soon after the final return of the ship to Sydney, from a severe illness contracted during the last cruise, but not till he had successfully accomplished the chief object of his mission, which was a more detailed examination of the Great Barrier Reef and adjacent coasts. The assistant-surgeon was Thomas H. Huxley, a name familiar to all, who achieved fame at this early period of his career by the zoological researches made during the voyage. The naturalist to the expedition and author of the "Narrative of the Voyage of the *Rattlesnake* during 1846-50" (1852) was John MacGillivray, who had held a similar position in the *Fly* Expedition, and who had thus through long official service become favorably known as a zoologist. The geological references in the "Narrative" are few, and consist merely of the names of rocks at certain observed stations.

GREGORY, A. C.—The discouraging nature of the interior of Australia, as made known by Sturt, and the utter disappearance of Leichhardt's Expedition of 1848, checked the progress of exploration for a few years; but in 1855 a successful effort was made to penetrate the interior from the north-west by the North Australian Expedition, which was fitted out by the Imperial Government, and was the last of the series. The expedition was placed under the leadership of Mr. A. C. Gregory, who was accompanied by Dr. (now Baron Sir F. von) Mueller as botanist, Mr. J. S. Wilson as geologist, and Mr. Elsey as surgeon. The party was conveyed by schooner to the mouth of the Victoria River, towards the exploration of which nothing had been done since its discovery by Wickham and Stokes. The Victoria River was ascended to its source in latitude $18^{\circ} 12'$, and the country to the south of the Dividing Range was explored beyond the northern limits of the great interior desert to latitude $20^{\circ} 16'$, longitude $127^{\circ} 30'$. The physiographic features of the Lower Victoria had been made known by the description of Stokes. The region about the Upper Victoria was found to consist chiefly of extensive valleys of good soil, well grassed, and of more arid sandstone tableland, varied with outcrops of basalt, the latter constituting rich grassy downs. The tableland rises abruptly from the coastal tracts, and attains an average elevation of 700ft. in the Sea Range, 900ft. in latitude 16° , 1,600ft. in latitude 18° , falling to 1,300ft. in latitude 19° and 1,100ft. in latitude 20° . By removal of the upper strata deep gorges, 600ft. in height, are formed, which open out into large valleys or plains. Mr. Gregory struck across from the Lower Victoria to the head of Roper River, and thence followed the base of the tableland from which he had descended, passing near the

sources of the rivers discharging into the Gulf of Carpentaria ; from the Albert River to Brisbane he followed Leichhardt's route of 1844. This extraordinary achievement is second to none in point of interest, of unknown country traversed, and of the scientific results gained ; a vast void in the geological map was filled in.

The geological structure of the gorges of the Victoria River inland from Sea Range (which had already been described by Stokes as consisting of horizontally-bedded sandstone overlying inclined metamorphic rocks) is described by Gregory* as follows :—

1. Thick bed of red sandstone, overlain by ironstone gravel.
2. Thick compact bed of siliceous sandstone, with indistinct stratification, generally exceeding 300ft. ; at Sea Range a softer whitish sandstone, 100ft. thick, separates this formation into three bands.
3. Bluish shale or clay slate.
4. Limestone of unknown thickness, covered with a stratum of jasper varying from a few inches to 60ft. in thickness.

WILSON† says—"The rocks composing the tableland are Palæozoic, and, with the exception of a few beds of trap and an occasional prominence of granite, belong to the Carboniferous." The siliceous sandstones he places on the horizon of the Hawkesbury series of New South Wales, but describes as differing from them in the absence of drift-bedding and organic remains. The cliffs on the north-west coast he regards as partially reconstructed ferruginous sandstone belonging to the Tertiary period.

Since Gregory's expedition the interior of Australia has been traversed in various directions, and with such efforts are honorably associated the names of Stuart, Burke and Wills, Warburton, Giles, J. Forrest, &c., but the geological gain has been of a purely local importance. I may therefore be pardoned if I single out for mention that recently fitted out by—

SIR THOMAS ELDER. The object—to fill up the blank spaces in the topographical and geological maps of Australia—was ambitious, and the scientific equipment of the expedition gave hope that permanent results would be gained ; but its premature disbandment has indefinitely protracted the realisation of this cherished consummation. So far as the area traversed is concerned the expedition accomplished a very great deal ; it was a failure simply by reason of the limitation of the original scheme. In geology nothing new has been brought to light, though certainty has

* Journal of the N.W. Australian Expedition, Parl. Rep. 1861.

† Journal Royal Geographical Society, vol. xxviii.

replaced previous guess-work or speculation. Nevertheless, such problems as the exact relation of the fossiliferous Silurian to those of older date, the stratigraphy and fossils of the marine Cretaceous, and its relation to the supra-Cretaceous rocks, still await solution. The geologist to the expedition has done his work so conscientiously and thoroughly that the poverty of his report* is to be ascribed to Nature's deficiencies. In other departments of natural history our expectations have been satisfactorily realised. May we hope that the Australian Macænas of our time will crown his efforts to unfold some of the mysteries of our dry interior by directing a systematic exploration of some well-defined area, such as the oasis of the Macdonnell Range?

DISCOVERY OF GOLD.

The year of 1851 marks an epoch in the history of Australia, because in that year the rich goldfield of Ophir was discovered. Gold was scientifically discovered by Strzelecki in 1839, and by Clarke in 1841, though its existence would appear to have been known as early as 1823. In 1844, without being aware of these discoveries, Sir Roderick Murchison pointed out the similarity of the rock structure of the Eastern Cordillera of Australia to that of the Ural Mountains, and predicted the occurrence of gold. Subsequent events afforded a proof that geology, like the more exact sciences, is capable of advancing philosophical inductions to very important results. But the precious metal was not commercially discovered, so to speak, till 1851, by Hargreaves, who had spent some of his earlier years as a stock-raiser in Eastern Australia. In 1849 he was gold-mining in California, and his experiences there gained convinced him of the similarity in structure of the auriferous rocks of California and certain districts in New South Wales. He revisited New South Wales early in 1851, to put to the test his geological instinct and the accuracy of his observations. In this he succeeded, and ultimately, under Government direction, the goldfield of Ophir, in the district of Bathurst, was declared open. He was awarded £10,000 for his discovery, and in 1876 a pension was granted him. He died in 1891 at the age of 75 years.

The discovery of gold proved a source of an enormous amount of wealth to New South Wales, and was soon followed in the same year by the discovery of much richer goldfields in Vic-

* Trans. Roy. Soc. S. Aust., vol. xvii., 1893.

toria, which had just then been separated into an independent colony. A powerful factor was thus added to the economic and scientific advancement of the continent. The consequent stimulus to a higher intellectual culture resulted in the foundation of the Universities of Sydney and Melbourne, and the establishment of systematically-organised geological surveys.

The University of Sydney was opened in October, 1852, but the study of geology was not introduced till 1866, Dr. Alex. M. Thomson being then appointed reader in geology and mineralogy, In 1870 he was made professor. On his death, in 1872, he was succeeded by Professor Liversidge, whose real work was always chemistry and mineralogy. In 1882, upon a redistribution of the subjects of the University curriculum, Mr. W. J. Stephens was appointed professor of natural history and lecturer on physical geography and geology. After his death, towards the close of 1890, the present professorship of geology and physical geography was inaugurated, and Mr. David, who had been assistant on the geological staff of New South Wales since 1882, was appointed to the chair in 1891.

The University of Melbourne was opened on October 3rd, 1855, and from its inception took a prominent place in the history of geological progress in Australia. To this I shall again refer in connection with the Geological Survey of Victoria.

Concurrently therefore with the memorable events just alluded to the history of geological progress enters upon a new period. Up to 1853 our exact knowledge of the sedimentary deposits, as derived from the organic remains, was confined to the Carboniferous, to a late Tertiary (represented by the *Diprotodon* period), and to a more recent *Æolian* formation; no distinct identification of Upper Silurian, Devonian, or Eocene had been forthcoming, though their existence was implied, whilst the only evidence of a Mesozoic epoch was a single imperfect example of a *Belemnite*. Restricted means of communication in a vast extent of country was the main cause which retarded advancement in geological investigation. With increasing population this barrier was gradually removed. Expansion of our pastoral occupation and the opening out of new trade routes brought new fields within the horizon of geological vision. It is, therefore, not a matter for surprise that in the next decade great and rapid advances were made in establishing a comparison on palæontological grounds with corresponding geological systems of Europe. The history of geological progress in the second half century is mainly that of the Geological Surveys; and the chrono-

logical treatment of my subject must be abandoned at this stage; but, in the form of an appendix, I have set forth a summary of discoveries and original researches in respect of the principal periods now known to be comprised in the table of the Australian Sedimentary Deposits.

GEOLOGICAL SURVEYS.

1. NEW SOUTH WALES.

So early as 1845 Strzelecki urged a regular geological survey under Government direction. The subsequent discovery of mineral treasures showed the importance of a minute and careful study of the rocks and minerals of the colony; and, finally, through the persistent advocacy of the Rev. W. B. Clarke, representations were made to the Home Government as to the expediency of instituting a mineralogical and geological survey of the colony. As a result of their representations, the appointment of geological surveyor was, early in 1849, offered to Mr. Beete Jukes (afterwards Professor and Director of the Irish Geological Survey), whose personal acquaintance with the geology of Australia made the selection a most desirable one, but it was declined; then Mr. Bristow, of the Geological Survey of England and Wales, accepted the offer, but, before the expiry of the term allowed him to prepare for his departure, he tendered his resignation; finally Mr. Samuel Stutchbury then curator of the Bristol Museum, was appointed, on the recommendation of Sir Henry T. de la Beche, Director of the Geological Survey of Great Britain, as being "well instructed in survey work, with great experience as a coal viewer, and a skilled mineralogist." Mr. Stutchbury arrived towards the end of 1850, and his first official field work was to proceed with Hargreaves to the alleged gold discoveries, and to make a searching examination into the conditions of their occurrences. A survey of the geological features of the gold-producing country occupied Stutchbury about two years; but during the latter part of his term of office he was chiefly employed in the southern portions of Queensland, particularly on the Ipswich coalfield, which he regarded as contemporaneous with that of Newcastle. The Palæozoic fossiliferous limestone on the western flank of the Blue Mountains, discovered by Mitchell, was referred on palæontological evidence to the Devonian—"Certainly older than the Carboniferous Limestone of Europe." The authors of the "Geology of Queensland," who hail Stutchbury as one of three worthy pioneers in Australian geology, have expressed the opinion that his sixteen reports

“display keen powers of observation, and are not so well known as they ought to be.”

Contemporaneously with Stutchbury, the Rev. W. B. Clarke was employed by the Government, commencing September, 1851, to ascertain the probabilities of the existence of gold in various parts of the colony. He arrived in New South Wales in 1839, being then 41 years of age; his labors as a geologist commenced some time before leaving the home country, and his first paper on Australian geology was communicated in 1842,* but he had already commenced the collection of rocks, fossils, and minerals, he having presented, in 1844, a set to the Woodwardian Museum of Cambridge University. In 1845 he accompanied Beete Jukes to various geological sections around Sydney, and much of the latter's definite account of the Carboniferous rocks of that part of New South Wales is traceable to Clarke; Leichhardt, in 1846, acknowledged his obligations to him. The part which he played in the discovery of gold I have already alluded to, and to it may be added that of tin in 1849. He did great good in educating the Government to understand how much the mineral resources of the colony were identified with the development of the knowledge of its rocks and minerals, and to him is chiefly due the credit of the establishment of a geological survey. Clarke contributed largely to the elaboration of the Siluro-Devonian and Carboniferous rocks in New South Wales and Queensland, and of the Cretaceous in Queensland. He was essentially a practical man, and while not caring very much about contributing to scientific knowledge for its own sake, yet he took a very keen interest in the progress of palæontological research in Australia, and his collection of Palæozoic fossils formed the subject of a detailed work† by Professor de Koninck, of Liege. The majority of his papers and reports were written in the interest of the mineral resources of the colony, and embrace an area of 100,000 square miles. Whilst respecting the enthusiasm of younger workers he was not always in sympathy with them, and allowed himself to be led into controversies, concerning the merits of which it is not fitting to enter here. He was elected F.R.S. in 1876, and was awarded the Murchison Medal of the Geological Society in 1877, “in recognition of his remarkable services in the investigation of the older rocks of New South Wales.” His last contribution to the geological literature of Australia, “The Sedimentary Formations of New South Wales,” was published in

* On the Fossil Pine Forest of Lake Macquarie, Proc. Geol. Soc., vol. 4, 1843.

- + “Recherches sur les Fossiles Palæozoïques de la Nouvelle Galles du Sud.” 1876-77.

1878; the introductory notice to which is dated June 2nd, 1878, only fifteen days before his death. That volume is an index to the immense services rendered by him to geology generally, although it is more particularly devoted to the Palæozoic rocks of New South Wales, to the study of which he had devoted forty years of his life. Now that fifteen years have passed since his death we are better able to make a true estimate of his real achievements than was possible at the time of their announcement. Though some of his observations have been corrected and some of his generalisations discarded, yet the solid mass of original work remains as a lasting memorial of his genius and industry. His name has become a household word amongst us, and will be handed down to posterity as that of the "Father of Australian Geology."

The geological and palæontological collections made by Clarke, as well as his maps and books, were acquired by the New South Wales Government at a cost of £7,000. This, as also the collection made by the Department of Mines at the instance of the Government Geologist, was destroyed by fire on September 22nd, 1882; thus maps, manuscripts, and authenticated fossils, the greater bulk of which had not been utilised up to that time, were absolutely lost.

On the resignation of Mr. Stutchbury at the end of 1855, a long interregnum succeeded, during which Mr. W. Keene, the examiner of coalfields and keeper of mining records, continued, in a certain sense, the geological survey, but the actual advancement in our knowledge of stratigraphical geology and palæontology is due to the Rev. W. B. Clarke, and to him alone. In 1873, Mr. C. S. Wilkinson, previously of the Geological Survey of Victoria, was appointed Geological Surveyor; and in 1875 the control of the Survey Branch of the newly-organised Department of Mines was vested in him. In 1880* the first geological map of New South Wales, based on the original map of the late Rev. W. B. Clarke, was issued by the Department. Some indication of Wilkinson's successful direction of the survey is to be found in his numerous official reports and maps, which evince intense application and high professional skill. His many papers contributed to scientific societies further display an untiring energy and zeal in the cause of his favorite science. The geology of New South Wales received very careful development at his hands, and a summary of its stratigraphy from his pen was published by the Department of Mines in 1887†. The classification of the Carboniferous rocks of

* Report Department of Mines for 1880, and separately issued in 1882.

† Notes on the Geology of New South Wales.

New South Wales proposed by the late Rev. W. B. Clarke has been elaborated, and to some extent modified in details and added to by the Geological Survey staff, especially by Wilkinson and David. The death in 1891 of this kindly and courteous gentleman, at a comparatively early age, was widely deplored. His successor is Mr. E. F. Pittman.

The appointment of Mr. Robert Etheridge, jun., in 1887 (formerly on the staff of the Geological Survey of Victoria, afterwards Palæontologist to the Geological Survey of Scotland, and later of the British Museum), as Palæontologist to the Geological Survey of New South Wales, is an admission of the value of palæontology in its application to the elucidation of the classification of the sedimentary deposits. The memoirs issued by the Department, under the editorship of Mr. Etheridge, which were commenced in 1888, have brought within reach of those interested in Australian geology most valuable results of palæontological investigation. The eighth memoir was issued last year. In addition, there was commenced in 1889 the issue of "Records of the Geological Survey," devoted to current discoveries and observations regarding the geology, palæontology, and mineral resources of the colony. These have been issued quarterly up to date, are highly appreciated, and cannot fail to stimulate research among amateurs who may have the opportunity to carry on geological investigations; whilst the authentic information imparted with regard to mineral occurrences and laboratory work in this connection makes them valuable commercially as well as scientifically.

2. VICTORIA.

Prior to 1851 Victoria offered comparatively little attraction to the immigrant, but the discovery of gold in that year arrested the tide of emigration, population rapidly increased, and commercial prosperity advanced by leaps and bounds. Mining registrars and surveyors were appointed. A Geological Survey was established under the direction of Mr. (now Sir) A. R. C. Selwyn, one of the ablest of the staff of the Geological Survey of Great Britain. The chief members of his field staff were the late Messrs. Aplin, Daintree, and Wilkinson; Messrs. Ulrich (now Professor), Norman Taylor, H. Y. L. Brown, R. Etheridge, jun., and R. A. F. Murray; whilst to Professor (now Sir F.) McCoy, who had been appointed to the chair of Natural History in the University of Melbourne, was entrusted palæontology.

Up to 1853 the geology of Victoria was almost a blank. What little was then known of it was due to Mitchell, Strzelecki, and Jukes, but that little was for the most part either misread or too indefinite to be available in the future. Thanks to the ability and zeal of Mr. Selwyn and the members of his staff, aided by the palæontological determinations of Professor McCoy, the geological structure of Victoria was rapidly unfolded, and large tracts of country were geologically surveyed in detail and illustrated by sixty-five admirably-executed maps on a scale of 2in. to one mile, each embracing an area of fifty-four square miles. In 1863 a general sketch map was published on a scale of eight miles to lin., and republished in 1867* in a reduced form. The Lower and Upper Silurian strata were recognised, and the line of demarcation drawn between them; the Avon River sandstones were referred to Carboniferous or passage-beds in that direction from the Upper Devonian; the limestones of Buchan and other isolated patches in Gippsland were classed as Middle Devonian; the coal-bearing strata of the Cape Otway and Western Port districts were tabulated as Jurassic. These determinations stand to-day; but the elaboration of the Bacchus Marsh beds and the Tertiary deposits is the work of later authorities. Selwyn made the first attempt to classify the Tertiary beds of Victoria, but as his classification was based on lithological characters, and as the palæontological data were not brought into relation with the existing marine fauna of adjacent areas, no high value can be attached to his determinations. Professor McCoy occupied himself with some of the Tertiary fossils, but they are, so far as published, too limited in number to serve as a basis of classification on the principle advocated by Sir Charles Lyell; other authors, with no local knowledge, have in their attempt to revise the classification, only made further confusion.

It is a matter of deep regret that in a spirit of parsimony the Victorian Parliament in 1868 abolished the Geological Survey, one of the most complete ever organised. The deprivation of the means of obtaining accurate information as to the mineral tracts which remained to be explored, was, however, to some extent removed in 1871, when the geological work was partially resumed under the direction of Mr. Brough Smyth, then Secretary for Mines, and subsequently under his successor, Mr. J. Couchman, and continued by Messrs. Norman Taylor, R. A. F. Murray, J. Dunn, and F. Krausé, assisted by Mr. A. W. Howitt (Warden of Goldfields) and W. Nicholas. Geological maps of the principal

* Interecolonial Exhibition Essays, plate I.

goldfields, and reports embodying geological descriptions of defined areas, were published, whilst illustrations of Palæozoology, by Professor McCoy, and of Palæophytology, by Baron von Mueller, were issued. In 1875 a "First Sketch of a Geological Map of Australia," by R. Brough Smyth, was issued under departmental authority.

In the beginning of 1878 the Geological Survey was again discontinued, but was resumed later, Mr. Murray being alone reinstated, and he still remains Government Geologist. Afterwards Mr. James Stirling was appointed on the permanent staff in 1887, and other assistants are occasionally engaged.

Since 1877 there has been a practical cessation of geological surveying on an organised basis. Nevertheless, a valuable piece of work during this period was the issue of a geological map of Australia and Tasmania, executed by Mr. A. Everett, chief draughtsman of the Mining Department.

The resignation of Mr. Langtree as Secretary for Mines in 1889 made room for the appointment of Mr. A. W. Howitt, so long favorably known for his geological investigations of Gippsland and for his anthropological memoirs. This transfer raised the hope that some return to the higher functions of a geological survey would be attempted. It has been realised in part, and the more recent geological reports, such as those on the coal formations of Gippsland, and on the glacial conglomerates of Heathcote, are evidence of the possibility that the more purely scientific aspects of geology can be carried on concurrently with its direct application to industrial economics. The severance of the two objects would be a lasting disservice to the material advancement of knowledge among the educated mining classes of the colony. The support given by our provincial Governments to geological science has for the most part been greatly disproportionate to its industrial importance. It is much to be desired that the geological reports of the Department of Mines should be rendered more accessible to the scientific reader by their separate publication, instead of being virtually lost amidst a mass of mining statistics of merely ephemeral value.

3. QUEENSLAND.

As already indicated, the labors of Stutchbury, and Clarke, extended into what is now Queensland. On the disbandment of the geological staff of the Victorian Survey in 1868, we find in that year Mr. C. D'Oyley Aplin appointed Geologist for the Southern District of Queensland, and Mr. Richard Daintree for the

Northern Division, both having been members of Mr. Selwyn's staff in Victoria. The former held office till 1870. In 1871 the latter proceeded to London in charge of the Queensland mineral exhibits at the exhibition of 1872, and remained there as Agent-General for the colony, a post he held until 1876, when in consequence of ill-health he was obliged to resign. In recognition of his services to the colony in his official capacity, and to colonial science, Her Majesty conferred on him the distinction of C.M.G. His well-earned honor was held for a very brief period, as he died in 1878. Daintree, aided by the palæontological determinations of Mr. Etheridge, sen., outlined the geology of Queensland in a paper*, accompanied by a sketch map, the first of its kind. The Silurian of previous authors is referred to the Middle Devonian, the coal formation of Northern Queensland is recognised as Carboniferous, the removal of the coal deposits characterised by *Taeniopteris* to the Mesozoic age is insisted on, the Ipswich Coal Measures are regarded as the equivalent of the Carbonaceous series in Victoria, the marine Mesozoic fossils of the River Flinders area are classed as Cretaceous, whilst his "Desert Sandstone" is regarded as Tertiary. The progress of the survey has not materially disturbed this classification. The chief emendations are the removal of certain areas classed as Devonian to the Carboniferous, and the transference of the Desert Sandstone—on palæontological data, though it was previously thought to be unfossiliferous—to the Upper Cretaceous.

Mr. A. C. Gregory, who explored the Gascoigne and Murchison rivers in 1848, directed the North-West Australian Expedition in 1856, headed the Leichhardt Search Expedition in 1858, and was formerly Surveyor-General for Queensland, held the appointment of Geologist for the Southern District from 1875 to 1879. His most important reports relate to the southern coalfields, and "that on the Ipswich coalfield is the most important published up to the present date, although it is one of the earliest." †

Mr. R. L. Jack, who had served ten years on the Scottish Geological Survey, was appointed in 1877 Geologist for Northern Queensland, and on the retirement of Mr. Gregory became chief of the staff for the whole colony. Mr. N. H. Rands joined him as assistant in 1883, and Mr. A. G. Maitland in 1888.

The present state of our knowledge on Queensland geology is succinctly and clearly set forth in the "Geology and Palæontology

* Quart. Journ. Geological Society, vol. XXVIII., 1872.

† Geology of Queensland, by Jack and Etheridge, p. 333, 1892.

of Queensland," by Messrs. Jack and Etheridge, published within the past twelve months. The issue of this work marks an event in the history of geological progress in Australia. It stands unrivalled for its rich stores of information, and for its methodical arrangement, tracing, as it does, the various steps in the growth of our knowledge, and giving credit to each previous observer who had contributed to its history. The reports of isolated surveys are pieced together, and the whole is illustrated by a large "geological map, which has been compiled with some approach to accuracy." The palæontological part is enriched with forty-four quarto plates of fossils.

4. SOUTH AND WEST AUSTRALIA.

The establishment of the geological surveys of these colonies came too late to render aid in the completion of the geological history of Australia, and what has been accomplished by them is local rather than general.

The foundation of the University of Adelaide in 1875 gave me the opportunity, as the occupant of the Chair of Natural History, of contributing to the knowledge of Australian Geology. In 1877 the discovery of a few fossil remains in strata where they were previously unknown revolutionised our ideas concerning the age of the crystalline rocks, which occupy an enormous extent and thickness in this continent. In consequence of the recognition of the Cambrian age of these fossils, the underlying unconformable metamorphic rocks were relegated to the Archæan.

The classification of the marine Tertiaries, after the method employed by Sir Charles Lyell, has gradually been evolved, and within the last three years four distinct populations have been made out, the relation of the beds containing them have been demonstrated, and the main divisions, corresponding with Eocene, Miocene, Pliocene, and Pleistocene, have been established. So have been filled in the last remaining large gaps in the chronological sequence of the Australian sedimentary rocks.

Thus in Australia, as in other continental areas, there are developments of Azoic, Palæozoic, Mesozoic, and Cainozoic rocks; and, moreover, the geological sequence of the chief marine formations are fairly well represented—from Archæan to Permo-Carboniferous, from Trias to Cretaceous, and from Eocene to those deposits now in process of accumulation. That there are gaps of considerable extent in Eastern Australia is certainly true, but they owe their existence to the prevalence of terrestrial conditions. These gaps are partly filled by marine Jurassic beds in West Australia

(discovered by Mr. F. T. Gregory in 1861*) and by the marine developments of the Cainozoic epoch in Southern Australia.

GLACIAL PERIODS IN AUSTRALIA.

Newer Tertiary Glaciation.—Prior to 1877 it had been conjectured by two geologists† that certain surface features might be attributed to ice action; but on May 7th of that year I announced, in a course of public lectures, the existence of a well-preserved glacier path along the edge of the sea cliffs at Hallett's Cove. The nature of the evidence at this locality and elsewhere in South Australia was brought to more scientific notice in 1879,‡ and subsequently supplemented in 1885§ and 1888.|| Observations in Victoria by several geologists¶ have geographically extended the phenomena of a late Tertiary glaciation in Southern Australia, though Hallett's Cove remains unique in respect of the magnitude and completeness of the glacial features which are there preserved. Geologists have been slow to accept the fact, and there have been those who have opposed and even ridiculed the notion of glaciation in such low latitudes and at such inconsiderable elevations, but to-day we may congratulate ourselves that a Post-Miocene glacial period occupies an unassailable place in the geological history of Australia. Mr. Jack** has lately added his testimony, as the result of personal inspection, that "Prof. Tate's observations are correct in every particular," and in addition has satisfied himself that the movement of the ice must have been from south to north, a conclusion that I had arrived at from the southerly position of the probable source of the morainic *debris*. This expression of opinion by a master in the art of interpreting glacial signs will, I am sure, carry conviction to the minds of those who till now have been sceptical; but if there be any here who are still adversely inclined, I beg them to withhold their decision until they have studied the features *in situ*. An opportunity is offered for that purpose by the excursion fixed for Saturday next, September 30th. "The interest appertaining to the discovery of a comparatively recent glacial epoch in Australia is, however, not alone of relative

* Quart. Jour. Geol. Soc., vol. xvii., p. 475.

+ Selwyn, Report Geology of S. Australia; 1859. Tenison-Woods, Geological Observations, p. 20. 1862.

‡ Trans. Roy. Soc., S. Aust., vol. ii., p. lxiv.

§ *Id.*, vol. viii., p. 49, 1866. || *Id.*, Aust. Ass. Adv. Sc., vol. i., p. 231.

¶ Howitt, Quart. Journ. Geol. Soc., vol. xxxv., p. 35, 1879; Griffiths, Roy. Soc. Vic., 1886; Stirling, J., Roy. Soc. Vic., 1855; *id.*, Proc. Lin. Soc., N.S.W., p. 483, 1886; Lendenfeld, Dr. R. von, Proc. Lin. Soc., N.S.W., 1885, p. 41; Howitt, A. W., Victorian Naturalist, vol. viii., 1891, p. 33.

** Geology Queensland, p. 619, 1892.

scientific value but it is of intrinsic value, as affording a clue to the unravelment of many highly complex biological problems relating to the distribution, evolution, and extinction of organic forms.*

Glaciation during Triassic Period.—Another geological period in Australia furnishes evidences of ice action, namely, that of the “Hawkesbury sandstone,” in the deposits of which occur, as first indicated by Wilkinson in 1879,† “angular fragments of shale, which have evidently been torn up by ice moving upon beds of shale and mingled in an irregular manner with the drifted sand which has formed the bed of sandstone immediately overlying the shale bed.”

Glaciation in Permo-Carboniferous Times.—Yet a third geological period, that of the Permo-Carboniferous, has been interrogated and has yielded evidences of glacial conditions on a large and far-extending scale. The Bacchus Marsh sandstones and conglomerates were referred by Selwyn,‡ in 1861, to a period intermediate between the Carboniferous and Permian, whilst the sandstones on the evidence afforded by their plant remains were assigned by McCoy to a Triassic age. From the character and mode of arrangement of the material of the Bacchus Marsh conglomerates, Selwyn§ suggested transport by glacial action, though at that time grooved or ice-scratched pebbles and rock surfaces had not been observed. The occurrence of breccias and conglomerates in the Carboniferous rocks of New South Wales subordinate to the “Upper Marine” beds had been previously noted, though their significance had not been indicated till Mr. T. Oldham|| (Deputy-Superintendent of the Geological Survey of India), when on a visit to Australia in 1885, discovered some ice-scratched pebbles among them, near Braxton, and correlated the conglomerates with the boulder group of Talchir of India, the Eccra conglomerates of South Africa, and the glacial conglomerates of Bacchus Marsh. Beds of similar aspect, and indicating a similar mode of origin, have been described by Jack¶ in the Bowen River coalfield, and by Rands** in the Gympie series. The proof of the glacial origin of the Bacchus Marsh conglomerates was indicated by Dunn††, who reported that “a conglomerate with such characteristics suggests glacial action.” The

* Stirling, J., Roy. Soc. Vict., 1885. . . . + Proc. Roy. Soc. N S.W., vol. XIII., p. 105, 1880.

‡ Exhibition Essays, p. 182. § *Id.*, p. 183.

|| Records Geol. Surv. India, vol. xix., p. 43, 1886; *Id.*, Geol. Mag., July, 1886.

¶ Report on Bowen River Coalfield, 1879; and Geol. Queensland, p. 151.

** Report on Gympie Goldfield, 1889; Aust. Assoc. Adv. Sc., 1., p. 297, 1889; also Jack, Geol. Queensland, p. 77, 1892.

†† Report Mining Department, Vict., 1888, p. 81.

same observer in 1890* and later†, in a beautifully illustrated memoir on the conglomerates at Wild Duck Creek, near Heathcote, supplies all the characteristics of glaciated rock surfaces and ice-scratched erratics; whilst still later similar appearances have been recognised in the conglomerates at Bacchus Marsh by Mr. G. Sweet.‡

The recognition of climatic zones in the Permo-Carboniferous and Hawkesbury Sandstone series permits, in conjunction with the distribution of the plant remains, the correlation of distant areas on the basis of contemporaneity. Whether or not the Indian geologists§ have pushed too far the value of such a time measure by its synchronous application to both hemispheres, I think we may safely employ it in the classification of our deposits, even if we do not accept a contemporaneous origin for the sequence of the sedimentary formations in South Africa between the Lower Carboniferous and the Uitenhage series.

IMPERFECTION OF THE GEOLOGICAL RECORD.

The diffusedness in the geographic distribution of the geological systems robs the field geologist of the means to determine the relationship that one set of beds has to another. Hitherto geological age has largely been determined by fossiliferous evidence, but deductions drawn therefrom may be subject to modification when the stratigraphical sequence has been ascertained. Palæontology is the handmaiden to stratigraphical geology, and though it may hold the key to the problems of local and comparative stratigraphy, yet it cannot afford results of permanent value when applied to widely separated areas. These methods of determination, when separately employed, gave discordant results in the case of the Newcastle Coal-series, and a controversy of long duration waged between the respective adherents of the opposite opinions entertained.

On the other hand, palæontology has usefully lent her aid by directing closer attention to stratigraphical details and has thus led up to the discovery of a break in the succession of deposits co-ordinate with the palæontological one; in this way, the separation of the Miocene from the Eocene on stratigraphical features has been attained.

* Aust. Assoc. Adv. Sc., vol. II., p. 452. + Report Mining Department, Vict., 1892.

‡ Victorian Naturalist, 1892, p. 130.

§ Dr. Oldham, Mem. Geol. Surv., India, III., p. 209, 1863. Dr. H. F. Blandford, Quart. Journ. Geol. Soc., vol. XXXI., p. 519, 1875. Dr. Feistmantel, Rec. Geol. Surv., India, XIII., p. 250, 1880. Dr. Waagen, Rec. Geol. Surv., India, XIX., p. 22, 1886. Mr. R. D. Oldham, Rec. Geol. Surv., India, XIX., p. 43, 1886.

We have nothing at all approximating to the imbrication of one system by another, as in the geological succession of the British strata, where each has a determinable base and cover. Here, it may be said, that for the most part we have neither base nor cover; the overlying system being, most frequently, vastly removed in time from that which underlies. Thus the Lower Cretaceous rocks of Australia rest directly on Archæan, Cambrian, or rarely Carboniferous; nowhere are they in actual sequence with the next older system, that of the Ipswich Coal-series. The Cambrian has no Palæozoic cover in Australia; the Upper Cretaceous beds are hundreds of miles away from the nearest marine Eocene. I consider, therefore, that the definition of the stratigraphical boundaries of our rock systems is one of the most important tasks which should occupy the attention of our Geological Surveys. The difficulty that besets the stratigraphical geologist is complicated by the phenomenon of groups of strata separated by a physical break having the same assemblage of fossils, as is the case with the Desert Sandstone and Rolling Downs Systems and between certain sub-divisions of the Permo-Carboniferous in Queensland and New South Wales.

The faunal peculiarities of the several formations are, moreover, such as to raise the question—are we right in adopting the chronology of the European School?

JUKES*, in speaking of the Palæozoic rocks and fossils of Australia, preferred always to speak of them only as Palæozoic, and forbore to discuss the question of their identity in time with the Silurian, Devonian, or Carboniferous periods of Europe, for which even the identity of one or two species (if it occurs) is not altogether sufficient evidence.

Perhaps we may not be far wrong in regarding our Cambrian and Ordovician as the homotaxial equivalents to those known by the same names in Europe; and though we have a fauna Silurian in its composite character, yet it does not present such a sub-division into life zones as is well known to the European student. The limits of the Silurian and Devonian, and of the Devonian and Carboniferous, seem so ill-defined that it is questionable if the middle term exists as viewed from a European or North American standpoint. Then we have the palæontological overlap of the Palæozoic and Mesozoic in the Newcastle Coal-series, and probably something analogous between Mesozoic and Cainozoic. Certainly

* Phys. Structure of Australia, pp. 21, 22; 1850. Man. Geology, 2nd. edit., p. 408; 1862.

there are remnants of a Cretaceous fauna in our Eocene, which are not derived from an endemic source, but are migrants from the European or Asiatic area, and altogether it appears to be older than that of its representative in the Northern Hemisphere, whilst there is reason for the belief that the terrestrial equivalents may be synchronous with some portion of the "Desert Sandstone," which in part has yielded a much impoverished Cretaceous fauna.

The attempts to bring the order of succession of the Australian stratified deposits in unison with that of the country in which so many of the geologists have gained their early impressions have at no time been satisfactory, and the difficulties are daily increasing. Even at an early period of our geological history there had been grasped the important idea that the geology of the typical area of Silurian, Devonian, and Carboniferous of Europe was not exactly comparable with that of Australia. This is indicated by the hesitancy on the part of authors to assign a given group of fossils to a definite epoch, and by the discordant results arrived at when the age has been the subject under consideration.

Despite the desire to cling to home associations, I think the time is fast approaching when it will be deemed advisable to found an independent school for Australian Stratigraphy. But before a complete revision of the chronological sequence of our rocks can be undertaken much stratigraphical and palæontological research will have to be brought within some measurable distance of finality. Nevertheless, may it not be possible to make a beginning on what is fairly well known? May we not decide to use such terms as Eocene and Pliocene, which, as expressions of the relative degrees of antiquity of their faunas, measured by the proportion of living species, do not commit us to the idea of correlation with divisions of similar denominations elsewhere? But the employment of the time word *Cretaceous* conveys the idea of specific community between the Australian deposits so named and their supposed exoteric equivalents, which barely exists, or at least only under such modification as to be undefinable. Such a term as *Permo-Carboniferous* is good up to a certain point, but it does not embrace what may be called the idiosyncrasies of its palæontology, and therefore, like Cretaceo-Eocene and other similar terms, is misleading, and must be regarded as of no permanent value. Mr. R. M. Johnston writes:—* "We must be content to work out the true association of local stratigraphy and local biology unimpeded by references to such associations elsewhere; we must establish the relationship

between the successive formations and their contained fossil remains; and we must not, in our eagerness for geological progress, expect to establish at once in Australasia such close harmonious relationships as have been determined in Europe by the accumulated labors of several generations of distinguished workers."

Discussing the subject of the nomenclature of the Australian Tertiaries, Professor Martin Duncan* says:—"It would be as well not to establish a too local terminology, for sooner or later the Cainozoic deposits of New Zealand, which attain probably a greater magnitude in depth than those of Australia, will be found to render the establishment of a great southern series necessary." So far as regards the magnitude of the Cainozoic beds, New Zealand has an advantage, but it may not be generally known that the Australian equivalents are much thicker than has usually been supposed. The Pre-Pliocene strata in the Croydon bore, for instance, near Adelaide, have a thickness of 2,200ft., and in the vicinity of Melbourne very considerable thicknesses of Eocene deposits have been proved. But, apart from this, the faunas of our Cainozoic formations are vastly richer than those of New Zealand, and of these and other geological periods the fossil contents are in course of careful elaboration and have largely been made diagnostically known; so that, considering the little progress which New Zealand has made in this direction, Australia is the more likely to furnish a standard for reference, at least for palæontology, if not for stratigraphical sequence.

CIRCUMSTANCES RETARDING GEOLOGICAL PROGRESS.

The study of geology for its own sake is extensively pursued in Great Britain. The science has its devotees in all ranks of the community, whilst its educational value is attested by its popularity. The official geologist draws largely upon his unofficial brother for local details of stratigraphy, whilst progress in palæontology is almost entirely dependent upon him. In Australia the enthusiasts have always been few in number. Thus, on analysis of Etheridge and Jack's "Bibliography of Australian Geology," I find the names of only 110 authors, covering a period of eighty years, who have contributed to our literature from personal observations made within our boundary. The last decade added from twenty to thirty, but at the present time I doubt if there be more than twenty workers outside the official ranks.

* Quart. Journ. Geol. Soc., 1870, p. 315.

“The harvest truly is plenteous, but the laborers are few.” The reasons for this are not far to seek; they have reference mainly to peculiarities in the geological structure of the continent.

Monotony and uniformity of animal and vegetable life over extensive areas is a characteristic of Australia, and its geology partakes of it, if indeed it be not a contributing cause. Thus we have a single formation spreading over a wide area—a sheet of rock covering hundreds of square miles. It is on this account that in an approximate way so much of the geology of Australia has been mapped, as it permits of observations made across one line of country being made applicable to large areas. In England a traverse from North Wales to London, which might be rapidly accomplished in a brief vacation, leads the amateur geologist from the base to the top of the geological series; while in this country months would be required to visit merely the localities of our chief systems, leaving out of consideration the time required to ascertain the mutual relations of the deposits. Thus compactness and variety of geological structure belong to English geology, whereas simplicity and diffusedness are Australian characteristics. Take any one of the chief centres of learning in Australia—how very imperfectly can students be taught in a practical way the law of succession of deposits and of life. Melbourne is the most favorably situated, but what does it offer within easy reach of the student? Lower Silurian and Upper Silurian, offering very limited opportunities for studying their structure, and none for studying their relationship; beyond these there are only isolated areas occupied by Eocene and overlying basalts, the whole constituting a few broken links of a geological chain.

Another deterrent cause affecting the popularity of the science is the comparative rarity of fossiliferous deposits, or at the least the prevailing paucity of organic remains. Fossil collecting makes the tyro geologist, and in the absence of this stimulus how can we hope to make geology attractive? Up to the present only a conspicuous few have been educated in Australia, and the majority of amateur geologists in Australia have brought their zeal and knowledge with them from the home country. The *Succession of Life in Australia* is a subject which offers a most inviting field for research, and largely concerns the geologist as well as the biologist, because it involves the question of the comparative value of different groups of fossils in marking geological time. In the Pliocene beds of this continent a rich marsupial fauna suddenly sprang into existence, and from that time to the present Australia

has been constantly occupied by this type of mammalian life in the greatest diversity of form. Whence its origin? Other and less familiar illustrations of biological import are at hand; and, though this subject is alien to my purpose, yet I introduce it in passing because of a circumstance cognate with the life history of our fossiliferous deposits. I allude to the remarkable paucity in fossil species, and absolute poverty in specialised genera, in all formations of the Palæozoic and Mesozoic epochs; only in the older Tertiaries does any great variety and abundance appear. It may be said that exploitation for fossils has been too infrequent to permit of a census of any one of the systems of those epochs. This is true to some extent in respect of a few of them, either from the newness of the discovery or the inaccessibility of their chief fossiliferous localities; but it does not satisfactorily explain away the difficulty when applied to the Ordovician, Silurian, or Carboniferous. The comparative barrenness of life in these geological periods would seem to imply that the conditions of life were too precarious, such as may have been caused by frequent oscillations of level, or possibly by climatic alternations, to permit of a high state of evolution. When, however, we pass up into the Eocene the circumstances are altered; there a fauna prevails very rich both in species and genera, representing a veritable population even exceeding in number that which occupies the same geographic area to day.

A third difficulty in the way of obtaining enthusiastic students is the absence of remunerative positions. Professional avenues exist, but it has hitherto been the practice of our geological survey departments to import men. This course may be excusable in the case of high-class officers, but surely under such tutelage as we can now offer our own students could be made available for minor services. Inducements beyond mere honors in an examination should be offered to our students, and then our University bodies would probably be able to retain their graduates beyond the time required for the ordinary curriculum. The issues involved have so direct a bearing on the future progress of geological and biological science in this country that it is hoped that through the intervention of this Association the implied reproach that we cannot educate our young men to the required professional standard may be removed. Lastly, I refer to the pernicious practice, happily less frequent of late, of remitting palæontological material for determination beyond our own circle of workers. Wherever elaboration is possible within the colonies let it be done, and only

when the necessary talent is wanting should we employ external aid. I think that it is only necessary to call attention to the existence of the evil, and appeal to the sense of justice and patriotism, to bring about the removal of an active cause inimical to palæontological progress. Palæontology in Australia has made great advances during the last twenty years, as witness the "Decades" issued by the Geological Department of Victoria, the various "Memoirs" by that of New South Wales, and the numerous contributions to several of our scientific societies.

ANTIQUITY OF CONTINENTAL AUSTRALIA.

It is a general impression that Australia is a very old continent. Undoubtedly it is, because it presents a range of the geological record equal to that of other continental masses. But this impression is based on illogical deduction, derived solely from the fact that certain characteristic types of the Jurassic fauna of the Northern Hemisphere still linger in the Australian area, such as *trigonia*, *ceratodus*, and *marsupials* among animals, *cycads* and certain *conifers* among plants. But the physiographic aspects of Australia have not always been absolutely continental. Since Upper Devonian times there have always been land surfaces, at any rate in Eastern Australia, where there was partial interruption to an absolute continuity (and the area locally affected is not relatively great) during the deposition of the Carboniferous series, which is, however, in a large measure littoral. It may safely be asserted that Australia, certainly so far back as the deposition of the extensive marine Cretaceous occupying the low level tracts of the interior, presented the aspect of a vast archipelago. At the close of that epoch, the various insular masses became welded together, so that the antiquity of Australia as a whole is only Post-Cretaceous. In early Eocene or late Cretaceous times the flora was of a cosmopolitan type, consisting of an admixture of generic forms, some of which are now proper to the temperate and sub-temperate parts of the Northern Hemisphere, such as oaks, birch, alder, &c., and others exclusively Australian, such as eucalypti, banksias, araucarias, &c. The differentiation of the Australian flora has therefore been brought about during Post-Eocene times.

Inferences as to the antiquity of Australia, drawn from its almost exclusive marsupial types, are erroneous, because there is every reason to doubt the correctness of the statement, thereby implied, that marsupials originated in Australia. Despite the recurrences of land surfaces from late Palæozoic times to the present day, and

it is not improbable that some of them may have been permanent throughout or for a greater part of that long interval, no marsupials as old as those of Europe and North America have yet been found; neither its coaly strata nor its ancient lake basins have yielded any of the higher types of fluviatile or terrestrial vertebrates. Indeed, the only instance of a fossil representative of the marsupialia, older than Pliocene in the Australian area, is that of a diprotodontoid in the Eocene beds at Table Cape, Tasmania, whereas we must look for a polyprotodontoid as the early ancestor of the class. Recent researches point to South America as the area from which the Australian marsupial fauna has probably been derived, especially as that country possesses in its Eocene marsupial fauna close alliances with certain existing polyprotodon-types in Australia. Intimately connected with the origin and distribution of life in Australia is the geological history of its past and present configuration, more particularly that of the interior.

PHYSICAL CHARACTER OF THE INTERIOR.

The observations of some of the earlier explorers gave rise to speculations as to the physical character of the interior, and when the facts became known they in turn served as a basis for certain hypotheses respecting the physiographic features of Australia at various past periods in relation to the distribution of its fauna and flora. The progress of our knowledge in these matters is worth relating, inasmuch as undue credit has been given to Alfred Wallace as the originator of a geological causation affecting the geographic distribution of our plants and animals.

VANCOUVER, 1791, writes:—"The principal part of this country appeared to be coral, and it would seem that its elevation above the ocean is of modern date, coral being found on the highest hills we ascended, particularly on the summit of Bald Head. Here the coral was entirely in its original state. In these fields of coral sea-shells were in great abundance."* Flinders gives the upper limit of the coral field at 400ft.† Peron regrets not having investigated the nature of the evidences, and it remained to Darwin‡ to rightly interpret the phenomena—thus, the corals become calcified branches of trees and the seashells are identified with a living land snail (*Bulimus melo*).

FLINDERS§, judging from the character and appearance of the coast along the Great Australian Bight, concluded that this

* Voy. of Discovery, vol. I., pp. 165-66. 1801.

† Voy. Terr. Aust., vol. I., p. 97.

‡ Volcanic Observations, 2nd edit.; Jour. of a Naturalist, 2nd edit., p. 450.

§ *Op. cit.*, vol. I., p. 93.

extensive seawall had been a coral reef raised by some convulsion of nature, and that an inland sea or low sandy country existed behind it. He had, however, not examined the rock formation, which was judged "to be calcareous, the upper third brown, the lower two-thirds white, in horizontal layers," and attributed that of Bald Head to the same. The calcified casts of stems of trees contained in it he considered to be corals, as Vancouver did.

OXLEY, when stopped in his westward progress by the marshes of the Lachlan and Macquarie, was led to infer that the interior was occupied by a shoal sea, an opinion participated in by Allen Cunningham.

MITCHELL's exploration in 1846 yielded conclusive proof of the desert nature of Central Australia.

STURT adopted the notion that the Australian continent had been an archipelago, that the interior plains had been sea beds, and that part of the interior was still occupied by a sea of greater or less extent, and very probably by large tracts of desert country. Thus the main object of the exploration of Central Australia undertaken by him in 1844-46 was to connect Lake Torrens with some more extensive and more central body of water, which he expected to find at or about sea level. He thought that he had found some confirmation of this in the fossiliferous beds of the River Murray, which he considered to have been drifted from the north and accumulated against a bar of granite crossing the river near to its entrance into Lake Alexandrina. Moreover, the general level of the Murray Plains—250ft. to 300ft.—corresponds with that at which the rivers of the western watershed of East Australia lose their character as such. Arguing from the disposition and extent of the sand ridges in the basin of Lake Eyre, he concluded that the winds had not formed them, though they had assisted in shaping their outlines, and he attributed their formation to water—supposing that originally the sand was a submarine deposition and that in the course of upheaval current-action made parallel breaches in the sandy floor in the direction of its flow.* He appeals to the marks of floods and violent torrents as evidences that the continent was at one time more humid than it now is.†

STOKES doubted the existence of an inland sea, but suggested that the central part of the continent is a vast desert, though the interior drainage may convert a portion into a lake.

EYRE, who had pointed out the incompatibility of the existence in the interior of an extensive area of water and the occurrence of

* Narrative Exped. Central Australia, vol. I., p. 381.

+ *Id.*, vol. II., p. 124.

excessively hot and dry winds blowing from the same quarter*, unwittingly committed a similar error to that made by Vancouver and Flinders, and gave support to the notion of an interior lacustrine area by referring the helices and bulimini, buried in the loess of the plateau of the Great Australian Bight, to fresh water shells†.

JUKES‡, though accepting the evidences of the existence of a great sea of low and level land occupying by far the larger portion of Australia, with the hilly districts rising from it like islands, yet rejects the idea of any expanse of water in much the same terms as Eyre used. But he holds the view of a partially submerged continent during the Tertiary period, and attributes the peculiarities in the geographical distribution of our plants and animals to isolation from this geological cause. These speculations of this able geologist are alluded to by Sir J. D. Hooker in his essay on "The Flora of Australia," p. ci., 1859.

MACGILLIVRAY § agrees with the views of those geologists who consider Australia to have formerly appeared as a cluster of islands, which became connected since the Tertiary epoch, so as to form what may now be considered as a continent.

STURT missed the focus of central depression, though subsequent discoveries proved him to be right as regards the existence of an inland sea, now vastly reduced in area from what it once had been. Eyre, Babbage, and Stuart added largely to our knowledge of the extent of the lacustrine areas and desert tracts of Central Australia. During Burke's expedition the limits of Sturt's "stony desert" were proved very little further north than the point reached by him; whilst the surface features of the country bordering the Lake Eyre basin on the east and north are described by Wills as consisting of:—Stony rises, which are probably formed of the detritus of the sandstone ranges deposited in undulating beds of vast extent; loam flats, which are such an important geological feature in this part of the country; and sandhills, composed of compactly-set red sand, which in some places have a uniform direction on the average N.N.E. and S.S.W. The Lake Eyre basin remained undelimited till surveyed by J. W. Lewis in 1874-5.

DUNCAN, Professor Martin ¶, by a misreading of the geology, assumed that the marine Tertiaries "reached far into the interior,

* Journ. Expeditions, &c., 1845, vol. i., p. 273; Journ. Roy. Geograph. Soc., 1846, xvi., pp. 200-211.

+ *Op. cit.*, vol. i., pp. 285 and 323. ‡ Physical Structure of Australia, pp. 81, 84, 95.

§ Voy. of Rattlesnake, vol. ii., p. 355. 1852.

¶ Quart. Journ. Geol. Soc. vol. xxvi., p. 70. 1870.

and that it is by no means improbable that the Tertiary sea divided West Australia from the eastern provinces," and again that "the vast central area of Australia was a sea having open water to the north, &c."

WALLACE* appropriates the idea that, "during the Cretaceous period, and throughout a considerable portion of the Tertiary epoch," Australia was divided into two principal insular masses, an eastern and a south-western, a suggestion which, as already indicated, originated with Sturt thirty-five years before, and was later adopted and supplemented by Jukes.

From independent observations I had arrived in 1879† at much the same conclusions as Sturt, though from different premises. At that time I was not aware of his labors in this particular direction and now make this tardy acknowledgment of Sturt's instinctive grasp of the nature and origin of the Lake Eyre basin. At the date mentioned I sought to connect the relative high humidity which prevailed in Central Australia, as indicated by the prevalence of *Diprotodon* remains, with the glacial conditions which prevailed farther south. Later ‡, largely as the result of personal knowledge, I endeavored to show that a vastly increased rainfall over what is now the arid region of Australia during the *Diprotodon* Period is demanded by the extinct rivers, circumscribed lacustrine basins marked by their coincident sandbeaches, and the remains of large herbivores, whilst the lacustrine origin of the low level deposits is indicated by the presence of crocodiles, turtles, and fish. The subter-structure of this vast lacustrine region, formed by the union of Lake Eyre and the smaller lakes to the east and south-east of it, is Lower Cretaceous, whilst its extent is limited by the so-called "desert sandstone," which almost entirely surrounds it. The last occupation of this region by a sea was during Lower Cretaceous times, and not, as has been currently held, during some parts of the Tertiary epoch. Indeed this lacustrine area in still vaster proportions existed during the accumulation of the Desert Sandstone; at least that part of the formation surrounding Lake Eyre must, from the land vegetation entombed in it, be regarded as of such an origin. Consequently I have elsewhere§ expressed the opinion that the isolation of West from East Australia, which existed while Central Australia was a marine area, was continued into late Tertiary times, not by geological, but by climatic conditions—by conversion of

* *Island Life*, p. 465, 1880.

+ *Trans. Roy. Soc. S. Aust.*, vol. 2, pp. lxi.-lxvii.

‡ *Trans. Roy. Soc. S. Aust.*, vol. viii., p. 49, *et seq.*

§ *Aust. Assoc. Adv. Sc.*, vol. i., p. 312, *et seq.*, 1889.

the depressed area into a vast fresh-water sea, to be followed in our own time by utter desiccation. The unconformity of the Desert Sandstone to the Lower Cretaceous of the country about the River Flinders induced Daintree, in 1872, to regard it as Tertiary, but he expressed no opinion as to the conditions of deposition of this widespread formation, which "did at one time cover nearly the whole of Australia;" but Mr. Etheridge* thought that the series was probably fresh water. The Rev. Tenison Woods† held that the Desert Sandstone was of æolian origin, and had even suggested that it was contemporaneous with the Hawkesbury Sandstone—both views being quite untenable. The Desert Sandstone has since been found to contain, near Cooktown, interstratifications of coal, and at Croydon marine fossils; and Mr. Jack‡ concludes that after the Rolling Downs formation (Lower Cretaceous) had been laid down in the comparatively narrow sea which connected the Gulf of Carpentaria with the Great Australian Bight, and converted the Australian area into two islands, a considerable upheaval took place. The denudation of the Lower Cretaceous followed; unequal movements of depression then brought about lacustrine conditions on portions of the now uplifted bottom of the old deep sea strait, and in other portions permitted of the admission of the waters of the ocean. Finally a general upheaval placed the deposits of the period just concluded in nearly the positions in which we now find them.

A subject of great interest in this connection is the age of the Desert Tableland of North and North-west Australia. Its structure has been well described by King (1826), Grey (1841), Stokes (1846), Jukes (1850), F. Gregory (1861), and Goyder, A. C. (1869). Its massive sandstones are represented by Jukes as of unknown age, but are supposed by him to be Palæozoic. Wilson, of Gregory's expedition, places them on the horizon of the Hawkesbury Sandstone. Hardman's description of the country from King Sound to the Leopold Range recalls that of Grey's, respecting the country adjacent to Hanover Bay, and in all probability the Carboniferous sandstone of Hardman extends thus far north. The characteristics of the quartzites of the Leopold Range are not applicable to the tableland sandstone of the Lower Victoria River, or of Arnheim's Land. If we approach these areas from the eastward there is much reason for the belief that the (tableland) sandstone is coterminous with the Desert Sandstone; this view was held by Tate§ and Tenison Woods||. The fossiliferous pebbles found by

* Quart. Journ. Geol. Soc., vol. xxviii., p. 324, 1872.

+ Proc. Roy. Soc. N. S. Wales, 1882.

‡ Parl. Paper, S.A., No. 63, 1882.

§ Geology of Queensland, 1892, p. 511

|| Parl. Paper, S.A., No. 122, 1886.

Leichhardt in the drainage area of the River Roper may indicate a Cretaceous formation rather than a Palæozoic one; Leichhardt reported finding "impressions of bivalves, one ribbed like a *Cardium*," whilst Jukes, without sufficient warranty, conjectured they may have been *Spirifera* or *Productæ*, and colored the area as probably Palæozoic. That two, if not three, geological epochs are represented by similar lithological and physiographic developments is not at all improbable; and the origin of the tableland sandstone may be sought in the denudation of the Carboniferous quartzites of the western coastal region, whilst the reconstruction of the tableland sandstone may have originated some of the minor sandstone formations on the north coast, as suggested by Wilson.

MICROSCOPIC PETROLOGY.

Geologists have been too busily engaged in reaping golden harvests in the domains of palæontology and stratigraphy to be much tempted by the allurements of chemical geology or microscopic petrology.

Professor Ulrich has on several occasions drawn attention to the desirability of the microscopic study of our rocks as an aid to the explanation of geological phenomena, especially because useful generalisations could be drawn from the characteristics of certain intrusive rocks. Mr. A. W. Howitt has been zealous in his researches in this direction, and has been of late ably supported by Mr. W. Anderson, Rev. Milne Curran, Professor David, and Mr. James Stirling. This modern method of petrographical research, when employed as an aid to stratigraphical investigation, promises to be a source of important discoveries in Australian geology, particularly in that portion of it relating to the history of our volcanic rocks.

SUMMARY OF DISCOVERIES AND ORIGINAL RESEARCHES.

FUNDAMENTAL ROCKS, OR ARCHÆAN.

The generalisation which has sought to sweep all the crystalline rocks of Australia into the great Silurian net has been broken down by the discovery of unconformably superimposed Cambrian strata; and though it by no means follows that the whole of the crystalline rock masses are of Archæan age, yet there are good reasons for the belief that those rocks which exhibit the phenomenon of regional metamorphism belong to one epoch. The chief

evidence is that they occupy parallel lines of elevation, having an approximate north and south bearing, as was first noticed by Jukes*, who remarks, "that to his knowledge there was only one exception in N.W. Australia"; but the metamorphic area of that region does not offer exceptional features in the strike of its rocks, as over considerable tracts in Arnheim's Land it has been found that the "axes of the ranges coincide with the direction of the strike," which is north and south in the northern part and north-west and south-east in the southern part†, and in the Kimberley district the strike is, according to Hardman‡, about W.N.W. to N.W.

The "primitive schists" and "primitive rocks" of such early observers as Peron, Oxley, Stokes, &c., probably all belong to the Archæan epoch. Of some of them we have actual knowledge, and the existence of crystalline stratified rocks has been made known by subsequent geologists. Strzelecki (1845) was the first to place them in subterposition to the fossiliferous strata. Other authors have speculated on their age from structural and lithological considerations.

BURR, in 1846§, says that "the rocks of which one (Mount Lofty) range is composed are those which belong to the Primary strata, probably corresponding to the Cambrian and Skiddaw systems of Sedgwick," because "they are apparently devoid of the evidence of the existence of animal and vegetable life during their formation." Jukes|| classed them as metamorphic.

TENISON WOODS, Rev. J. E.¶, thought the same rocks "to be probably of either Cambrian or Silurian formation," but went on to say that "this is mere guesswork, supported by little more than resemblances in mineral character, &c."

SELWYN placed the basal parts of the Mount Lofty chain as the equivalents of Upper Silurian, and higher beds as more resembling the Silurian of the Victorian goldfields.** The metamorphic rocks of the Alpine region of Victoria were classed as Lower Silurian, but considering their prevailing strike, N.N.W., their lithological resemblance to those of the Adelaide chain, and the possibility of the altered aspect of the Lower Silurian being due to contact metamorphism, there is presumptive evidence that the main mass

* Brit. Assoc. Report for 1846-7; and Physical Structure of Australia, 1850, p. 79.

† Tate; S.A. Parl. Paper, Northern Territory, 1882, p. 2 and map 2.

‡ W.A. Parl. Paper, Geology of Kimberley District, 1884.

§ "Remarks Geology S. Aust.," p. 4 (Adelaide). || Phy. Structure.

¶ Trans. Phil. Soc., Victoria, 1858, pp. 168-176.

** S.A. Parl. Paper, Geol. Notes on S. Aust., 1860, pp. 1 and 2.

of these metamorphic rocks is Archæan. Resemblances in mineral character are at their best very unsafe guides, and we have in this instance an actual betrayal into a most serious error as a result of trusting in them.

SELWYN* placed the metamorphic rocks of the extreme western limits of Victoria as "possibly a true Cambrian or Azoic series." And again, "perhaps the rocks of some of the larger areas mapped as metamorphic represent Cambrian or Laurentian series."†

JUKES‡ says it is highly probable that the gneiss and mica schists which form the mountain chains of Australia belong wholly or in part to the Pre-Cambrian periods, and this affords another instance of the marvellous geological instinct possessed by this able geologist.

GEIKIE, A.S., referring to the opinion of Selwyn and others that the crystalline schists are metamorphosed Palæozoic formations, adds, "but there are not improbably other areas referable to an Archæan series."

HARDMAN|| provisionally classed as Lower Silurian or Cambro-Silurian the metamorphic rocks of the Kimberley district, W.A., but adds that "it is not improbable that these rocks, as well as similar formations in this colony and the other Australian colonies, may be of Laurentian age."

CLARKE¶ was of the opinion that there is not sufficient evidence that Azoic rocks exist in East Australia, and that some of the gneiss so placed by Strzelecki are merely products of transmutation.

APLIN considered the granite of Severn River, Queensland, as of metamorphic origin, quoted by Daintree.**

It is only in South Australia and West Australia that the metamorphic rocks are actually known to be Pre-Cambrian, but those elsewhere, unless they can be shown to be transmuted Palæozoic rocks, may be most conveniently referred to the same period.

The grandest exemplification of the Archæans is in the Mount Lofty Range of South Australia. These rocks occupy there a vast monocline, with a dip to the south-east, of not less than ten miles in thickness. One noteworthy lithological feature is the more highly developed metamorphism of the upper strata, mica schist, gneiss, and granite, succeeding in an ascending series clay slates, quartzites, and limestones. This exceptional phenomenon was

* Exhibition Essays, 1861.

+ Cat. Rocks, National Museum, 1868, p. 33.

‡ Manual Geology, 2nd edit., p. 434, 1862.

§ Text-book of Geology, p. 640, 1862.

|| W.A. Parl. Paper, Geol. Kimberley District, 1884, p. 6.

¶ International Exhib. Essays, 1867, p. 381.

** Quart. Journ. Geol. Soc., 1872, vol. xxviii.

recorded by Jukes in 1850—"The prevailing south-easterly dip would put the clay slates under the gneiss, mica, and chlorite slates," and independently observed by Selwyn in 1860. The non-acceptance of this view by the Government Geologist of South Australia has compelled him to reverse the order of succession, and he classes the lower series as "Silurian (and Devonian), metamorphic in part," and relegates the upper to "Palæozoic or Azoic, highly metamorphic."*

The elevated portions of the wide extending folds of the Archæans have produced our mountain topography, and have supplied the principal material of the newer deposits, all of them terrigenous, which fill the troughs of their plications and conceal the continuity of far distant axes of elevation. Our now ruined Mount Lofty chain must have formed a lofty watershed in Lower Palæozoic times. The first of the deposits are the Cambrian, which are much more broken and plicated than the underlying and embracing Archæans, probably as the result of the continuation of the earth movements after their deposition. These were then compressed by the contractions of width in the synclinal folds. The whole area of Australia seems to have been in a state of comparative quiescence since the period of those earth movements which resulted in the plication of the Archæans, and in the crumpling of the Lower Palæozoics. Since then it seems to have undergone oscillation of level within very narrow limits, and the depressions which have taken place never brought more than the margins of insular areas beneath the level of the sea.

Victorian Palæozoic physical geology in its broadest features is represented by Mr. Selwyn † as consisting of a great crumpled, contorted, and broken synclinal trough of Silurian and older strata, overlain unconformably by an equally extensive broken and undulating anticlinal arch of Upper Palæozoic rocks.

CAMBRIAN.

(a) *South Australia.*

1879. TATE (Trans. Roy. Soc. S. Aust., vol. II., pp. xlviii. and 77) refers the fossils collected by Mr. Tepper, at Ardrossan, Yorke Peninsula, to Lower Silurian, employing the term in the Murchisonian sense, though the Menevian series is implied. More detailed evidences of a Cambrian fauna at that and other localities are supplied by—

1884. WOODWARD, H., Geol. Mag., p. 343.

* Geological Map of S. Aust., 1884.

+ Intercolonial Exhibition Essays, 1867, p. 153.

1890. ETHERIDGE, R., jun. (Trans. Roy. Soc., S. Aust., vol. XIII., p. 10).

1892. TATE (*id.*, vol. xv., page 183).

(b) *West Australia.*

1890. ETHERIDGE, R., jun. (Geol. Mag., VII., p. 97), describes an *Olenus* and a *Salterella* from the Kimberley district as Cambrian.

LOWER SILURIAN.

(a) *Victoria.*

1858. SELWYN (Quart. Journ. Geol. Soc., vol. XIV., p. 533) drew the line of demarcation between the auriferous graptolite slates and Upper Silurian, which MCCOY had shown to have faunas characteristic of the corresponding series in Europe, and thus established the fact of the specific identity of the two faunas over the whole world.

(b) *Central Australia.*

Fossiliferous limestone, discovered in the Macdonnell Ranges by C. Chewings (Trans. Roy. Soc. S.A., vol. XIV., p. 249*, 1891) was referred by TATE, *id.*, p. 255, to Upper Silurian, and by R. ETHERIDGE, jun. (Parl. Paper, S.A., No. 158, pt. 9†, 1892, No. 23, 1892; No. 50, 1893), to Lower Silurian.

(c) *West Australia.*

The existence of Silurian rocks forming the Mount Barren Range, as reported by F. T. Gregory (Quart. Journ. Geol. Soc., vol. XVII., p. 479), has not been proven; whilst the clay slates and schists described by H. Y. L. Brown (Parl. Paper, W.A.) may be Archæan; at any rate, their Silurian age has not been conclusively determined.

UPPER SILURIAN.

(a) *New South Wales.*

(YASS AND HUME SERIES.)

1838. MITCHELL, Major T. ("Three Expeditions," &c.), discovered coralliferous limestones about Yass Plains.

1840. VERNUEIL (Bull. Soc. Geol. de France, XI., p. 177) recorded Silurian fossils from New Holland [probably from Murrumbidgee, *teste* W. B. Clarke, "Sedimentary Formations," 1878.]

1845. MORRIS (in Strzelecki's "Phys. Description," p. 296) considered the limestone about Yass Plains [and Shoalhaven] as the probable equivalents of the Devonian system in Europe.

* Read June 2nd, 1891.

† Submitted September 9th, 1891.

1848. CLARKE, W. B. (Quart. Journal. Geol. Soc., iv., pp. 63-66), notes discovery of Trilobites, especially *Trinucleus*, and other Silurian fossils at Yarralumla. "These and the Yass beds, if not Silurian, are at the very base of the Devonian System."

1851. CLARKE, W. B. (Geol. Surv., Report No. 56, p. 85), refers to the limestones at Bungonia, Shoalhaven River, "as not younger than the Wenlock rocks."

1856. SALTER declared the fossils from Yass to indicate "a true U. Silurian formation."

1860. CLARKE, W. B. ("Researches Goldfields of New South Wales"), demonstrated the existence of the U. Silurian rocks at a large number of localities; he says that the fossils "will still be sufficient to justify the assertions respecting the extent to which rocks of the Silurian Epoch, especially of the upper beds, are developed in the gold-bearing regions to the southward."

1867. CLARKE, W. B. (Intercol. Exh. Essays, pp. 381-382), demonstrated "the existence of at least U. Silurian on both flanks of the southern part of the Cordillera."

1877. DEKONINCK ("Foss. Pal. de la N.G. du Sud") refers the fossils of Burrawang, &c., to U. Silurian.

1878. CLARKE, W. B. ("Sed. Formations," &c., p. 16), declared the formation at Bowning to be Devonian, from the occurrence of *Calceola sandalina*.

1878. JENKINS, C. (Proc. Lin. Soc., N.S.W., vol. III, pp. 21-32), describes fossiliferous strata around Yass, dividing them into Yass and Hume Series, and considers the age to be U. Silurian.

1879. TAYLOR, Norman (Geol. Mag., vi., pp. 399 *et seq.*), considers the bedrock of the Cudgegong diamond field to be either of U. Silurian or Devonian age, more probably the latter, on palæontological grounds.

1880. WILKINSON, C. S. (Report Depart. Mines, N.S.W., p. 216), placed the Yass Series in the Silurian.

1880. HECTOR, Sir J. (Journ. Roy. Soc. N.S.W., xiii., p. 70), correlates the Yass and Hume beds with U. Silurian.

1883. DAVID, T. W. E. (Report Depart. Mines, N.S.W. for 1882, p. 148), who surveyed the U. Silurian area around Yass, shows that the beds form a continuous series.

1886. MITCHELL, John (Proc. Lin. Soc., N.S.W., pp. 577 and 1059), points out that typical U. Silurian trilobites occur at Bowning with and above the so-called *Calceola sandalina* [*Rhizophyllum interpunctatum*, Dek.], and that the same beds also yield graptolites. [See also, Proc. Austr. Assoc. Adv. Sc. I., pp. 291-297.]

1892. ETHERIDGE, R., jun. (Geol. and Pal. Queensland, p. 45), states that a L. Devonian age has been ascribed to various rocks in New South Wales which are now believed to be U. Silurian.

(b) *Victoria.*

1850. JUKES ("Physical Structure") classed the slaty rocks about Port Phillip as Palæozoic.

1856. U. Silurian fossils were signalled in the basin of the Yarra by the Geological Survey Staff; but Blandowski (Phil. Soc., Vict., 1857) claims to have been the first to discover fossils in the Silurian sandy slates about Melbourne.

"CAVE LIMESTONE" OF NEW SOUTH WALES.

This term is used provisionally by the Geological Survey for an extensive series of beds on both flanks of the Cordillera, but the stratigraphical and palæontological relationships to Upper Silurian, Devonian, and Carboniferous have yet to be determined.

1820. OXLEY, John ("Two Expeditions," &c.), discovered this limestone at the sources of the Lachlan and Macquarie.

1821. BUCKLAND, Dean (Geol. Trans., vol. v., p. 480), referred to it as resembling "transition limestone."

1831. CUNNINGHAM, P., reported the limestone about Bathurst as fossiliferous.

1833. STURT, Capt. C. ("Two Expeditions," &c.), quoted it as coralliferous.

1838. MITCHELL, Major ("Three Expeditions," &c.), referred the "Cave Limestone" to the Carboniferous of Europe. See also Report, Geol. Survey, No. 121, p. 43 (1851).

1845. MORRIS (in Strzelecki's "Phys. Descript.," p. 296) referred to the Palæozoic deposits at [Yass Plains and] Shoalhaven as the probable equivalents of the Devonian System of Europe.

1851-2. STUTCHBURY, S. (Rep. Geol. Surv., N.S.W., No. 22, p. 28; *id.* No. 23, p. 35; *id.* No. 9, p. 29), referred this formation on palæontological evidence to the Devonian, "certainly older than the Carboniferous limestone."

1852. LONSDALE considered the coral fauna to be Devonian.

1867. CLARKE, W. B. (Intercol. Exh. Essays, p. 383), noted that some of the fossils of the limestones or "Passage Beds," to the westward of Wellington have the Carboniferous types and others the Silurian.

1870. THOMPSON, DR. A. M. (Journ. Roy. Soc., N.S.W., p. 57), remarked that the fossils of the lower stratified deposits about Goulburn are closely allied to Upper Silurian forms, but in the higher strata to the westward the fossils make an approach to Carboniferous types.

1878. JENKINS, C. (Proc. Lin. Soc., N.S.W., III., pp. 21-32), refers to the thick black limestone of Cave Flat, Murrumbidgee, as of Devonian age.

1886. WILKINSON, C. S. ("The Railway Guide of N.S.W."), proposed to include the limestone of the Jenolan Caves under the name "Siluro-Devonian."

1887. WILKINSON, C. S. ("Geol. of N.S.W." p. 54), thinks they may be classed with the highest beds in the Silurian Series.

1889. MITCHELL, John (Aust. Assoc. Adv. Sc., I., p. 296), describes the Cave Flat beds, and throws doubt on their supposed Devonian age.

MIDDLE DEVONIAN.

(a) *Victoria.*

1867. MCCOY (Intercol. Exh. Essays, p. 327) correlated the limestones of Buchan and Bindi, in Gippsland, with the European M. Devonian.

1874. MCCOY (Geol. Surv., Victoria, vol. II., p. 72) added the Tabberaberra shales to the Middle Devonian group in Gippsland.

1876. HOWITT (Geol. Surv., Victoria, III., pp. 181-249) established the sequence of the Devonian and Carboniferous strata in North Gippsland, and introduced the Snowy River porphyrites as Lower (?) Devonian.

(b) *Queensland.*

1847. LEICHHARDT discovered fossiliferous limestone at the Burdekin River, which were referred by W. B. Clarke to Upper Silurian (Journ. Overland Exped.).

1869. APLIN, in his "Report on the Upper Condamine," regarded the Palæozoic rocks on the eastern ranges of Queensland as Silurian.

1872. DAINTREE (Quart. Journ. Geol. Soc., vol. XXVIII., p. 288) regarded the greater part, especially the Burdekin and Fanning River limestones, as Devonian.

1872. ETHERIDGE, R. (*id.*, p. 324) massed the fossils from two distinct horizons (the Middle Devonian of Burdekin Valley and Gympie Series) as Siluro-Devonian.

1892. JACK (Geol. and Pal. of Queensland, II., p. 45) correlates the Devonian of Queensland with the Bindi and Buchan limestones of Gippsland.

(c) *West Australia.*

1890. FOORD, NICHOLSON, and HINDE, Messrs. (Geol. Mag.), determined a suite of fossils from Mount Pierre, near Fitzroy River, Kimberley District, to belong to Devonian.

[The conglomerates capping the Darling Range, and doubtfully referred to Devonian by F. T. Gregory (Quart. Journ. Geol. Soc., 1861, p. 475), may be Mesozoic, as suggested by R. Etheridge (Quart. Journ. Geol. Soc., vol. XXVIII., p. 320, 1872).]

UPPER DEVONIAN.

(a) *Victoria.*

1867. SELWYN (Intercol. Exh. Essays, p. 160) refers the Iguana Creek beds to an age inferior to the Bindi limestones.

1874. MCCOY (Geol. Surv., Vict., Report II., p. 73) determines them, on the evidence of the fossil plants, as Upper Devonian.

1876. HOWITT (Geol. Surv., Vict) shows that they are superior and unconformable to the Bindi limestones, and inferior to, but conformable with, the Avon River sandstones. The stratigraphical position of the Mount Tambo beds is for the first time shown to be Upper Devonian.

(b) *New South Wales.*

1875-8. WILKINSON, C. S. (Philadelphia Exh. Essays, 1875, p. 134; Report Depart. Mines. New South Wales, for 1877), describes the Rydal section as presenting a thickness of not less than 10,000ft., and states that, though classed as Devonian, its stratigraphical horizon is not definitely known.

1887. WILKINSON, C. S. (Geol. of New South Wales, p. 56), holds the same opinion.

1892. ROSS, CLUNIES (Austr. Assoc. Adv. Sc., vol. IV., p. 336), considers that in the neighborhood of Bathurst *Lepidodendron Australe* was probably of Devonian age.

1893. PITTMAN, E. F., and DAVID, T. W. E. (Proc. Lin. Soc., New South Wales, p. 121), announce the discovery in the neighborhood of Mount Lambie of a species of *Lepidodendron* below marine beds with *Spirifera disjuncta*. [This species—a Devonian fossil in Europe—was first indicated as Australian by Stutchbury (Geol. Surv. Report, No. 10, p. 8, 1853).]

CARBONIFEROUS.

(a) New South Wales.

1821. BUCKLAND, Dean, considered the coal formation of the Hunter River analogous to that of England (Geol. Trans., vol. v., p. 480).

1824. SCOTT, Archdeacon, referred the strata of the Newcastle coalfield to the coal formation ("Annals Philosophy").

1845. STRZELECKI ("Physc. Desc., New South Wales") places the Newcastle Coal Series in his Third Epoch, and thus detaches it from the underlying marine series (p. 123).

1845. MORRIS, in Strzelecki's Physc. Desc., expressed the opinion that the fossil flora presents a Jurassic facies, whilst the deposits containing the mollusca may probably belong to the Carboniferous (p. 296).

1848. MCCOY determined seventeen fossil plants and eighty-three mollusca. The plant-beds he classed as Oolitic, noting that there was no trace "of any characteristic fossil of the old coal of Europe or America." The fossil shells he referred to a Carboniferous age (Brit. Assoc. Adv. Sc. for 1847).

1849. DANA (Geolog. Report Wilkes' Exped.) included as component members of a great Carboniferous series the Sydney sandstone, the coal formation, and the "Sub-Carboniferous" argillaceous sandstone. The coal formation of Illawarra and Hunter River is stated to be probably Permian.

1850. JUKES ("Physc. Structure," &c.) says these coal-bearing beds are believed by some geologists to be of much later date (Oolitic) than the beds below them. "All the physical characters and relations of the rocks, however, led me to look upon the whole series as one great continuous formation."

1850. CLARKE (Quart. Journ. Geol. Soc., vol. IV., pp. 60-63) announced the occurrence of Palæozoic genera of plants in the inferior part of the Carboniferous System, and this is reiterated in Quart. Journ. Geol. Soc., vol. XI., p. 408, 1855.

1853. STUTCHBURY confirms Clarke's discovery, and figures a *Lepidodendron* in his Report on the Geology of Liverpool Plains (p. 9), and it was later confirmed by J. S. Wilson (Quart. Journ. Geol. Soc., vol. XII., pp. 283-288, 1856), and—

1865. KEENE (*id.* vol. XXI., p. 139, 1865), who considers the coal measures to be as old as those of Europe. Moreover, the later discovery of *Glossopteris* and *Phyllothea* with fossils of Carboniferous age by Clarke, Daintree, and others, both in New South Wales and Queensland, removed all doubt as to the

Palæozoic age, at least of these genera which had been so strenuously questioned by several writers.

1866. CLARKE (Quart. Journ. Geol. Soc., vol. XXII., p. 439) classified the coal measures and associated strata as follows:—

Hawkesbury Series.

Upper Coal Measures.

Upper Marine Beds.

Lower Coal Measures.

Lower Marine Beds (with Palæozoic plants).

1867. KEENE (Intercol. Exh. Essays, p. 396) holds that the Lower Coal Measures are older than any in Europe, and that the opinions “that the lowest intercalate with Silurian fossils and a Devonian flora are untenable.”

1876 MCCOY limits the term Carboniferous to the beds in New South Wales which are below those with *Glossopteris*, and to the *Lepidodendron* beds underlying the Lower Marine Series (Geol. Surv., Victoria, Report III., pp. 57-59).

CLARKE attributed a Silurian age to the slates and quartzites which cross into Queensland at the heads of the Severn River. These are referred by Jack to the Gympie Series (Geol. and Pal., Queensland, p. 74, 1892).

1878. CLARKE (Remarks Sed. Formations, p. 66) removed the Hawkesbury Series from the Carboniferous.

1880. WILKINSON (Dep. Mines for 1879, p. 216) applied the term Permian to the Upper Coal Measures, and that of Carboniferous to the subordinate beds.

1881. FEISTMANTEL (Foss. Flora, Gondwana Syst., vol. III.) regards the Newcastle beds as Lower Trias.

1883. TENISON WOODS (P.L.S., N.S.W., vol. VIII. pp. 52-53) refers the *Lepidodendron* beds, in part, to Lower Carboniferous, whilst the *Glossopteris* beds are referred—the lower portion to Permian (?) and the upper to Trias. (?).

1887. FEISTMANTEL (Sitz. K. Bohm. Ges. der Wissen.) classified the Carboniferous Series of New South Wales as follows:—

Permo- Carboni- ferous	{	Newcastle beds or Upper Coal Measures	Permian
		Marine Series	Upper and Middle Carboniferous
		Upper Marine beds	
		Lower Coal Measures	
		Lower Marine beds	
		{ <i>Lepidodendron</i> beds.....	Lower Carboniferous

1892. JACK (Geol. and Pal., Queensland, p. 142) considers the *Lepidodendron* beds of New South Wales to be approximately on the horizon of the Star Series in Queensland.

(b) *Queensland.*

Component Formations.—The Gympie, Star, and Bowen River (Lower, Middle, and Upper) series. (Jack and Etheridge, Geol. and Pal. of Queensland, 1892, p. 70, *et seq.*)

I. BOWEN RIVER SERIES.

1847. LEICHHARDT ("Overland Exped.") discovers coal beds at Bowen River.

1872. DAINTREE (Quart. Journ. Geol. Soc., vol. XXVIII., p. 286) recognises the Carboniferous age of the rocks and fossils of the Bowen river and other northern coalfields.

1879. JACK (Report on Bowen River Coalfield) sub-divides the series into three formations.

1880. ETHERIDGE, R., jun. (Proc. R. Phys. Soc., Edinb., v., p. 319), considers the L. and M. Bowen River formations to homotaxially represent the Carboniferous and Permian of Europe, and proposes to call the series Permo-Carboniferous.

1892. The authors of the "Geology and Palæontology of Queensland," p. 71, apply the term Permo-Carboniferous to the whole of the similar formations in Queensland and New South Wales.

II. GYMPIE SERIES.

1867. APLIN (Report, Auriferous Country, Upper Condamine) discovers fossiliferous rocks at Lucky Valley and Gympie, which he regarded as Silurian.

1868. CLARKE, W. B. (Proc. Roy. Soc., N.S.W., vol. I., p. 7), refers the rocks and fossils on the Mary River, at Gympie, to some part of the Carboniferous.

1872. DAINTREE (Quart. Journ. Geol. Soc., XXVIII., pp. 286, 289) recognises the Carboniferous age of the Don River fossils, but refers those of the Gympie mining district to the Devonian.

1879. GREGORY, A. C. (Report Geol. Features, S. E. Queensland, p. 7), classes the altered slates of Moreton Bay and Darling River Downs and the Gympie beds as Devonian.

1886. JACK (Handbook Geol. of Queensland) names the Gympie beds, removes them to Lower Carboniferous, and transfers to them all of the previously so-called Silurian and large areas hitherto regarded as Devonian.

1892. JACK and ETHERIDGE (Geol. and Pal., Queensland, p. 97).—The former thinks it likely that some of the cave limestones

of New South Wales may prove to be on the Gympie horizon, and the latter that the Gympie beds will prove to be identical with the New South Wales strata, termed by him "Carboniferous," and formerly known as "Lower Carboniferous." The lower formation of the Bowen River Series is believed to be newer than the Gympie beds.

III. STAR SERIES.

1872. DAINTREE (General Report, Northern District, p. 7) places the Mount Wyatt plant-beds, with their interstratified marine beds, as Upper Devonian (also Quart. Journ. Geol. Soc., XXVIII., p. 289, 1872).

1878. JACK names the rocks of the Star River basin the "Star beds," and regards them as of Upper Devonian age.

1883. WOODS, J. E. T. (Journ. Roy. Soc., New South Wales, XVI., p. 179), announces the discovery of plant-remains in the strata of the Drummond Range, Central Queensland, and ascribes the age to the Lower Carboniferous.

1886. JACK (Handbook Geol. Queensland) describes the Dotswood beds, and places them as conformably succeeding Middle Devonian.

1889. JACK (Report Sellheim Silver Field) refers to the Star beds those rocks which are regarded as Lower Carboniferous.

1892. JACK (Geol. and Pal., Queensland, p. 140) groups the whole of the above deposits under the head of the "Star Beds," and he considers these superior in position to the Gympie beds.

(c) *Victoria.*

Component formations:—(I.) Bacchus Marsh sandstones and conglomerates; (II.) Avon River sandstones.

I. BACCHUS MARSH SANDSTONES AND CONGLOMERATES.

1861. SELWYN (Vict. Exh. Essays, p. 182) refers the series to a period intermediate between the Carboniferous and Permian.

1867. MCCOY (Intercol. Exh. Essays, p. 327) refers the sandstones to the Lower Mesozoic, but considers them as probably inferior in position to the coal beds [of Victoria].

1868. SELWYN (Cat. Rocks, Nat. Mus., p. 44) speaks of the series under Upper Palæozoic.

1873. SMYTH, R. B. (Internat. Exh. Essays, p. 20), regards the *Gangamopteris* beds at Bacchus Marsh as nearly the equivalents of the Sydney Sandstone.

1879. FEISTMANTEL, DR. O. (Foss. Flora, Gondwana System, vol. III., pt. I., p.p. 31-32), regards the Bacchus Marsh sandstones as the representatives of the Upper Coal Measures of Newcastle.

1886. OLDHAM, R. D. (Rec. Geol. Surv., India, vol. XIX), correlates the conglomerates with the Talchirs of India and the Carboniferous marine beds of New South Wales.

II. AVON RIVER SANDSTONES.

1861. MCCOY (Vict. Exh. Essays) correlates them, on palæontological evidence, with Carboniferous "or passage beds in that direction from the Upper Devonian," adding that the limits of the Upper Devonian and Carboniferous are not clear where they occur in superposition, there being an insensible gradation from one to the other.

1867. MCCOY (Intercol. Exh. Essays, p. 327) says that the sandstones were the only traces of the Carboniferous formation which he could recognise in Victoria.

1892. JACK (Geol. and Pal. of Queensland, p. 142) says the *Lepidodendron* beds of the Avon River may be approximately on the horizon of the Star Series of Queensland.

(d) West Australia.

1841. GREY, Lieutenant, discovered Carboniferous rocks in the Victoria Range ("Two Exped.," &c.)

1849. SOMMER traced the coal formation from the head of the Irwin to Moore River, 160 miles, and noted the absence of limestone (Quart. Journ. Geol. Soc., vol. v., pp. 51-53).

1857. GREGORY, A. C., states the coal formation to occur in four areas, between the Irwin and Murchison Rivers and in another to the east of King George Sound (Trans. Phil. Soc., Victoria).

1861. GREGORY, F. T., showed that the Carboniferous to the north of Irwin River is overlain by Mesozoic strata (Quart. Journ. Geol. Soc., vol. XVII.)

1876. SMYTH, Brough, remarks that no rocks of Carboniferous age had been discovered in West Australia (Geol. Surv. Victoria, Report III., p. 61).

1884. HARDMAN reported a large development of Carboniferous rocks in the Kimberley district, namely, Carboniferous Limestone of about 4,000ft. thick and containing marine fossils, overlain by Carboniferous sandstone of about 1,000ft., yielding Palæozoic plants (Parl. Paper, W.A., No. 31, pp. 8-10).

LOWER MESOZOIC.

 (a) *New South Wales.*

Component Formations.	Sydney Area.	River Clarence Area.
I. Clarence Series . .	{ Narrabeen or Chocolate Shale Estheria Shales Wianamatta Shales	{ Coal Series at Dubbo
II. Hawkesbury Series	{ Hawkesbury or Sydney Sandstone	

I. CLARENCE SERIES.

1852. STUTCHBURY (Geol. Surv. Report) describes the coal-bearing beds at Dubbo, which were by him, as well as by Clarke (Geol. Surv. Report, No. 8, p. 7, 1853), referred to as Carboniferous.

1875. WILKINSON (Philadelphia Exhib. Essays, p. 125) suggested that the Clarence River coal-bearing shales are the equivalents of the Mesozoic coal strata of Victoria, and that they are a long way above the Newcastle coal beds.

1880. WILKINSON (Depart. Mines for 1879, p. 216) places the Clarence Series superior to the Wianamatta shales, and as belonging to Jurassic. Pittman expresses the same view (Dept. Mines for 1880, p. 244).

1883. TENISON WOODS, Rev. J. E. (Proc. Lin. Soc., N.S.W., vol. VIII., pp. 53 and 54), places the plant beds at Ballinore, near Dubbo, as Rhaetic or Lower Lias, and those at the Clarence River as Jurassic.

1885. CURRAN, Rev. J. Milne, places the Clarence Series, on the evidence of the plant-remains, between the Upper Coal Measures and the Hawkesbury sandstone (Proc. Lin. Soc., N.S.W.)

1886. WILKINSON and DAVID (Department of Mines for N.S.W. for 1885, p. 130) discovered fossil plants in the Narrabeen shales, and correlated them and the Estheria shales with the Clarence Series.

1890. WILKINSON, C. E. (Pal. Memoir, No. 3, Depart. Mines N.S.W., p. 41, 1890), discovered that the coal-bearing series of the Clarence River district underlay the Hawkesbury formation.

II. HAWKESBURY SERIES.

1810. BAILLY, in Peron's "Voy. Terres Aust.," describes the Sydney sandstone and Parramatta [Wianamatta] shales.

1825. LESSON ("Voy. La Coquille") referred the Sydney sandstone to Tertiary, and noted its superposition to the Coal Measures.

1845. STRZELECKI ("Phys. Description," &c.) expressed the same opinion.

1849. DANA includes the Sydney sandstone as a component formation of the Carboniferous Series.

1850. JUKES (Phys. Structure) included the Hawkesbury Series in the Permo-Carboniferous, but separated the Wianamatta shales from the underlying Sydney sandstone.

1865. KEENE (Quart. Journ. Geol. Soc., vol. XXI., p. 138) names the upper beds of the Sydney sandstone (= Wianamatta shales) the "false Coal Measures."

1867. CLARKE (Intercol. Exh. Essays, p. 389) was disposed to transfer the Hawkesbury Series to the Trias.

1876. MCCOY regards the Upper Coal Measures and the overlying Hawkesbury Series as parts of one great Oolitic Series (Geol. Surv. Victoria, Report 3, pp. 57-59).

1878. CLARKE ("Sed. Formations," p. 66) removes the Hawkesbury Series from the Carboniferous and refers it to an undefined period of the Mesozoic, but at the same time calls it Supra-Carboniferous. Feistmantel's view of the Triassic Age of the Hawkesbury Series, based on the nature of the flora, was accepted by—

1880. WILKINSON (Rep. Depart. Mines, N.S.W., for 1879, p. 216).

1881. FEISTMANTEL (Proc. Roy. Soc., N.S.W., vol. XIV., p. 106) correlates the Hawkesbury Series with the Talchir beds of India and the Bacchus Marsh sandstones of Victoria, on account of the glacial phenomena presented by each. A correction made by WILKINSON (Rep. Depart. Mines for 1880, p. 241).

1882. TENISON WOODS, J. E. (Journ. Roy. Soc., N.S.W., vol. XVI., pp. 53, &c.), holds the opinion "that the Hawkesbury sandstone is a wind-blown formation."

1886. STEPHENS, Prof. (Proc. Lin. Soc., N.S.W., 2nd ser., vol. I., p. 932), refers to the discovery of Labyrinthodonts in the Hawkesbury sandstone as accentuating its Triassic age.

1890. The assigned Triassic age of the Hawkesbury Series gains support from Mr. A. S. WOODWARD's study of its fish-remains (see his Memoir, Depart. Mines, N.S.W.)

(b) Carbonaceous Series of Victoria.

1828. HUME is the reputed discoverer of the Cape Patterson Coal Series.

1840. Coal of excellent quality discovered at Western Port (Proc. Geol. Soc., III., p. 495).

1846. STOKES ("Discoveries in Australia") considers the Cape Patterson and Western Port Coal Measures analogous to those of the Carboniferous.

1850. JUKES ("Physical Struct.") regards the coal-bearing formation about Western Port and west of Geelong as Palæozoic.

1858. SELWYN (Quart. Journ. Geol. Soc., XIV.) regards the series as Oolitic (?).

1861. MCCOY and SELWYN (Victorian Exhib. Essays, pp. 165 *et* 186) place the plant-bearing beds at Cape Patterson and Bellerine in the Mesozoic.

1867. SELWYN (Intercol. Exh. Essays, p. 164) reiterates his conviction that they are newer than Palæozoic, and may be representative of the Wianamatta shales of New South Wales.

1867. CLARKE (Intercol. Exh. Essays, p. 389) is disposed to place the Victorian Carbonaceous Series above the Wianamatta shales.

(c) Coal Series of Leigh's Creek, South Australia.

1889. BROWN (Parl. Paper, S.A.) refers them, with a doubt, to Cretaceous.

1891. ETHERIDGE, Jun. (Parl. Paper, S.A., No. 158, p. 9), places them under Lower Mesozoic (see also *loc. cit.*, No. 50, p. 8, 1893).

(d) Trias-Jura. of Queensland.

1892. MESSRS. JACK and ETHERIDGE ("Geol. Queensland") classify the Lower Mesozoic into (I.) Burrum Coal Formation, and (II.) Ipswich Coal Measures.

I. BURRUM COAL FORMATION.

1870. GREGORY, A. C., reports on the Burrum coalfield (Rep., &c.).

1872. DAINTREE (Quart. Journ., Geol. Soc., vol. XXVIII., pp. 283-284) includes this formation with the Ipswich coal series under Mesozoic.

1870. GREGORY, A. C., reports on this series as developed at Wide Bay and Burnett River (Report Geology of).

1883. TENISON WOODS (Proc. Lin. Soc., N.S.W., vol. VIII., pp. 53-54) places the Burrum coal formation as U. Lias (?), beneath the Ipswich coal series, and above those of the Burnett River which he classed as Rhætic or L. Lias.

1886. JACK (Geological Map) refers the series to the Trias.

1890. RANDS (Report on Tiaro District) shows that the Burrum beds rest unconformably on the Gympie beds.

1892. JACK (Geol. Queensland, p, 312) classifies them as Lower Trias-Jura.

II. IPSWICH COAL MEASURES.

1828. CUNNINGHAM, A. (Proc. Geol. Soc., vol. II., p. 109, 1834), discovers coal on the Brisbane River.

1872. DAINTREE (Quart Journ. Geol. Soc., vol. XXVIII., p. 283) insists on the removal of the Queensland coal deposits characterised by *Teniopteris* to Mesozoic, and regards the Ipswich coal formation as the equivalent of the Carbonaceous Series of Victoria.

CARRUTHERS (*id.*, p. 356) refers the plant remains to the Oolitic period.

1876. GREGORY, A. C. (Report Coal Deposits, &c.), exhaustively describes the Ipswich coal fields.

1883. TENISON WOODS (Proc. Lin. Soc., N.S.W., vol. VIII.) expresses his belief "that no very clear line of separation can be made between the coal beds of Newcastle and Queensland," p. 97; "at present the Newcastle beds are regarded as Palæozoic, and those at Ipswich as Mesozoic; I cannot find any such clearly marked distinctions," p. 98; but, at p. 54, he refers the Ipswich formation to Jurassic, and correlates therewith the "Carbonaceous of Victoria and the Hawkesbury sandstone."

1886. JACK (Geol. Map) regards the Ipswich beds as Jurassic;

1892. And (Geol. Queensland) classes them as Upper Trias-Jura.

(e) *Marine Series, West Australia.*

1861. GREGORY, F. T. (Quart. Journ. Geol. Soc., vol. XVIII., p. 475), discovers Mesozoic rocks with Ammonites, Trigonias, &c., overlying Carboniferous coal measures in the basin of the Gascoyne River and near Champion Bay. They are referred with a doubt to Cretaceous.

1862. JUKES (Man. Geol., 2nd edit., p. 593) says that the fossils discovered by Gregory "seem more like those of the Oolitic series than any others."

1863. MOORE, C. (Brit. Assoc. Adv. Sc., p. 83), observes that the bulk of the Mesozoic fossils are of Jurassic age.

1870. The same author (Quart. Journ. Geol. Soc., vol. XXVI., p. 226, *et seq.*) more fully elaborates the fossils, describing several new species, and establishes a large community of species between England and West Australia.

UPPER MESOZOIC.

CRETACEOUS.

Component formations according to Jack and Etheridge:—

Upper Cretaceous, Desert Sandstone (including Maryborough beds); Lower Cretaceous, Rolling Downs Formation.

(a) Queensland.

1848. MITCHELL ("Journ. Inter-tropical Australia") notes on his chart the occurrence of a *Belemnite* near Mount Abundance, Fitzroy Downs.

1861. MCCOY ("Exhibition Essays," p. 166) determines a collection of fossils from Wollumbilla, submitted by Clarke to be "the marine equivalents of exactly the same age as that I assign to the plant beds, *i.e.*, not older than the base of the Trias and not younger than the lower part of the Great Oolite." The Triassic genus *Myophoria* is quoted as evidence of that age.

1862. CLARKE (Quart. Journ. Geol. Soc., vol. xviii., p. 246) announced the existence of marine Mesozoic rocks at Wollumbilla, based on the fossil determinations by McCoy; but regards the beds as "altogether above the coal-beds of the Hunter River."

1865. KEENE (Quart. Journ. Geol. Soc., vol. xxi., p. 130) refers *Belemnites* and shells from the River Belliando (Belyando) to the Cretaceous epoch.

1865-1868. MCCOY submits tangible evidence of the Cretaceous facies of the marine Mesozoic rocks about the head of the Flinders River (Trans. Roy. Soc., Victoria, vol. vi., pp. 42-46; *id.*, vol. vii., pp. 49-51; *id.*, vol. viii., p. 41; *id.*, vol. ix., pp. 77-78; Annals Nat. Hist., 1865, vol. xvi., p. 333; *id.*, 1867, vol. xix., p. 335; Intercol. Exh. Essays, 1867, p. 325), though the Wollumbilla fossils are still retained as Oolitic (Intercol. Exh. Essays, 1867, p. 327).

1867. CLARKE (Intercol. Exh. Essays, p. 388) states on the authority of European geologists that the Wollumbilla fossils are really Cretaceous.

1870. MOORE (Quart. Jour. Geol. Soc., vol. xxvi., pp. 226 *et seq.*) describes the fossils from Wollumbilla, referring them to Jurassic.

1872. DAINTREE (Quart. Journ. Geol. Soc., vol. xxviii., pp. 278, &c.) describes the rocks of the Flinders area, classifying them as Cretaceous; the Maryborough beds are placed at the base of the Cretaceous and overlying the Burrum coal series.

ETHERIDGE (*id.*) describes the fossils, and refers those from Gordon Downs, near Roma, and those from Wollumbilla to the Oolite, p. 325.

1880. HECTOR, Sir James (Proc. Roy. Soc., N.S.W., vol. XIII., pp. 70, *et seq.*) places the Flinders River beds as the equivalent of the Neocomian of New Zealand.

1883. TENISON WOODS (Proc. Lin. Soc., N.S.W., vol. VIII. p. 55) regards the Desert Sandstone as an æolian formation of Jurassic age.

1889. JACK (Aust. Assoc. Adv. Sc., vol. I., p. 205) attaches the Desert Sandstone to the Cretaceous on palæontological evidence, as demonstrated by R. Etheridge, jun. It had been referred by Daintree, *op. cit.*, to Cainozoic, because "above and unconformable to the Cretaceous of the Flinders area."

1892. JACK and ETHERIDGE ("Geology of Queensland") classify the Cretaceous as above tabulated.

(b) *Central Australia.*

1849. STURT (Expd. Central Aust.) records fossiliferous limestone about Grey Range.

1863. WATERHOUSE, F. G. (Parl. Paper, S.A., No. 125, pp. 2-3) records fossiliferous argillaceous rock in the Lake Eyre basin, and refers it to Tertiary.

1877. TATE (Quart. Journ. Geol. Soc., vol. XLII., p. 258) records the occurrence of *Belemnites Australis* and other Jurassic (?) fossils at Stuart Creek, Lake Eyre.

1879. The same author (Trans. Roy. Soc., S. Aust., p. xlix.) expresses the opinion that the Wollumbilla type, to which the Lake Eyre fossils belong, approximates to a Cretaceous facies.

1882. WILKINSON adds Cretaceous to his Geological Map, the north-west country, embracing the western tributaries of the Darling, being so colored.

1883. BROWN, H. Y. L. (Parl. Paper, South Australia, No. 146), colors the area between Lake Frome and Cooper Creek as Cretaceous covered by Tertiary.

1884. The same geologist, in his Geological Map of South Australia, represents the vast area around Lake Eyre as "Mesozoic (Cretaceous and Oolitic), with or without overlying Tertiary beds."

1884. HUDDLESTONE (Geol. Mag., vol. I., No. 8, p. 339) refers some fossils from Lake Eyre basin to Mesozoic, none being absolutely decisive of their age, but quotes Mr. Etheridge, jun., for the opinion that they are Cretaceous.

1889. TATE (Aust. Assoc. Adv. Sc., vol. I., p. 228) rectifies the errors made by Moore in identifying certain of the Wollumbilla

fossils with Jurassic species, and submits further evidence of their Cretaceous age.

(c) *West Australia.*

1861. GREGORY, F. T. (Quart. Journ. Geol. Soc., vol. xvii., p. 475), offers the first positive evidence of the occurrence of Mesozoic fossils in Australia, and, though his discovery relates with certainty to the Jurassic, yet it probably embraces Cretaceous as well, as the chalky limestones with flints and *Ventriculites* near Gingin doubtless belong to that period.

1870. MOORE, C. (Quart. Journ. Geol. Soc., vol. xxvi.), thinks that there is evidence sufficient to show the presence of Cretaceous rocks as well as Jurassic.

CAINOZOIC.

Component Systems.

[Tate and Dennant, Trans. Roy. Soc. S. Aust., vol. xvii., June 1893.]

PLEISTOCENE.—Raised beaches—Æolian calciferous sandstones and limestones.

NEWER PLIOCENE.—Elevated shell beds—South-east from Mount Gambier and at Limestone Creek, W. Victoria.

Osseous breccias and mammaliferous drift of the Diprotodon Period.

OLDER PLIOCENE.—Marine sands beneath mammaliferous drift of the Adelaide Plain.

MIOCENE.—Upland Miocene plant beds, South Australia; low-level marine beds—Gippsland Lakes, upper beds of the Muddy Creek section, oyster banks of the River Murray cliffs, and Aldinga Bay.

EOCENE.—Clays and polyzoal limestone—Rivers Mitchell, Tambo, &c.; Sale; Gippsland; Port Phillip Bay; around the Carbonaceous area of Cape Otway; Camperdown; Muddy Creek, Hamilton.

Polyzoal limestone—Mount Gambier, River Murray, St. Vincent Gulf, Great Australian Bight.

Plant beds at Vegetable Creek, New South Wales—Plant beds inferior to the older basalts of Victoria.

EOCENE.

1810. PERON (Voy. Terres Australes) describes the fossiliferous limestone at Kingscote, Kangaroo Island.

1833. STURT (Two Expeditions, &c.) refers the formation of the cliffs of the Lower Murray River, on fossil evidence, to Eocene.

1845. STRZELECKI (Physical Descript., &c.) classifies the Eocene polyzoal limestone at Port Fairy as a raised beach.

1854. SELWYN (Proc. Roy. Soc. Tasmania, p. 169) considers the fossils at Schnapper Point to resemble those of the Paris basin and London clay.

1859. SELWYN (Quart. Journ. Geol. Soc., vol. xvi., p. 147) provisionally adopts the following classification of the Tertiaries [Eocene] in Victoria: 3. Newer Pliocene.—Flemington red Tertiaries, marine (like the Red Crag). 5. Miocene—Corio Bay, Cape Otway Coast, Murray Basin, and Lower Brighton beds. 6. Eocene—East Shore of Port Phillip, Muddy Creek, &c.

1859. TENISON WOODS (Quart. Journ. Geol. Soc., vol. xvi., p. 259) describes the Mount Gambier limestone, and thinks the formation of an Eocene character. BUSK (*id.*, p. 260) regards the polyzoa as indicating an age equivalent to the Coralline Crag of England.

1861. MCCOY (Vict. Exh. Essays, p. 168) believes the Geelong beds to be Lower Miocene and those at Schnapper Point to be Upper Eocene [afterwards altered to Oligocene in accordance with revised classification of the Older Tertiary of Europe].

1862. TENISON WOODS (Geol. Obs., S. Aust., p. 82) compares the fossils of the Mount Gambier limestone with those of the European Upper Eocene and Lower Miocene.

1865. TENISON WOODS (Quart. Journ. Geol. Soc., vol. xxi. p. 393) regards the Mount Gambier limestone as not so modern as the Coralline Crag, but younger than the Muddy Creek beds, and the Murray River beds as of intermediate age.

1868. SELWYN (Descrip. Cat. Nat. Museum) classes the rocks of Bird Rock Bluff as Upper Miocene and Lower Miocene, and correlates the Mount Gambier series with Upper Miocene (p. 55); the clays at Schnapper Point are classed as probably Upper Eocene, (p. 56), the Flemington fossiliferous sandstones as Older Pliocene and the limestones of Moorabool River as Miocene (p. 61).

1872. SMYTH, R. B. (Vict. Exh. Essays, p. 13) refers the fossiliferous beds at the Glenelg River and near Camperdown to Miocene.

1874. MCCOY (Geol. Surv. Vict., Report No. 2, p. 72) places the Bairnsdale limestone as "Middle Eocene, such as Corio Bay and Bird Rock, Geelong." HOWITT (*id.*, p. 62) uses the phrase Middle Tertiary.

1876. SMYTH, R. B., and MCCOY (Geol. Surv. Vict., Report 3, p. 81) provisionally adopt the following divisions [of what is

believed by Tate and Dennant to be the component formations of one series]: Lower Pliocene. Marine beds—Near Flemington; Miocene—Bird Rock, Boggy Creek near Sale, Bairnsdale, coastline from Princetown, at Curdies River, Cobden, Maude; Oligocene—Schnapper Point, Princetown, near mouth of Gellibrand River, near mouth of Aire River, at Cape Otway.

1878. TATE (Trans. Roy. Soc. S. Aust., vol. I., pp. 90-97 and 120) divides the Older Tertiary of the Aldinga and River Murray Cliffs into two series, Eocene and Miocene.

1880. HECTOR, Sir James (Proc. Roy. Soc., N.S.W., vol. XIII., p. 70 *et seq.*), correlates the Schnapper Point, Murray River, and Table Cape beds, with the Oamaru Series of New Zealand (Upper Eocene); the beds at Portland with Pareora beds (Lower Miocene); and the limestones of the Great Australian Bight with the Wanganui and the Awatere beds (Upper Miocene).

1888. JOHNSTON, R. M. ("Geology, Tasmania"), places the marine Older Tertiary of Victoria—Cape Schank, Bird Rock, Muddy Creek—and that of the River Murray Cliffs as the equivalents of the Table Cape beds (Eocene).

1889. DENNANT, J. (Trans. Roy. Soc., S. Aust., vol. VI., p. 30, *et seq.*), recognises two separate zones in the Muddy Creek beds, and correlates the older with the Schnapper Point clays.

1889. COSSMANN, M. (L'Annuaire Geol. Universelle), declares that the Gasteropod fauna of the Older Tertiary of Australia has incontestable analogy with that of the Paris basin.

MIOCENE.

1874. MCCOY (Geol. Surv. Vict. Report 2, p. 72) places the fossiliferous beds at Jemmy's Point, Gippsland Lakes, on the horizon of Pliocene, and, as the equivalent of the Wanganui series of New Zealand. Howitt (*id.* p. 60) uses the phrase Upper Tertiary.

1890. DENNANT, J. (Proc. Roy. Soc., Vict., p. 53, *et seq.*), correlates the strata at Jemmy's Point with the younger series (Miocene) at Muddy Creek.

For other references, see under "Eocene."

OLDER PLIOCENE.

1890. TATE (Trans. Roy. Soc., S. Aust., vol. XIII., pp. 172-184) elaborates a fauna from strata passed through in the Dry Creek and Croydon bores, near Adelaide. He regards it as younger than Miocene, and provisionally calls it Older Pliocene.

NEWER PLIOCENE OR PLEISTOCENE.

1886. DENNANT, J. (Trans. Roy. Soc., Vict.), describes beds in South-Western Victoria containing about 20 per cent. of extinct species.

1884. BROWN, H. L. Y. (Geol. Map of S. Aust.), colors as Lower Tertiary a large area in the south-east of the province which is certainly not older than Pleistocene.

INTERCALATED IGNEOUS ROCKS.

L. OR M. DEVONIAN.

The Snowy River felstone porphyrites, felstone ash, and agglomerates are described, and their stratigraphical position is assigned by Howitt, A. W. (Geol. Surv., Victoria, Report 3, 1876).

M. DEVONIAN.

Felsite breccias and felsite tuffs with a compact sheet of compact felsite and one of basalt are described by Howitt, A. W. (*op. cit.* Report No. 5, p. 117), as interstratified with the Buchan limestones.

U. DEVONIAN.

Interbedded melaphyres beneath the Avon River sandstone are described by Howitt.

PERMO-CARBONIFEROUS.

Diabasic and felsitic tuffs, together with sheets of felsitic and diabasic basalt, are interstratified with the Rhacopteris beds in New South Wales (David, Aust. Assoc. Adv. Sc., vol. iv., p. 67, 1893), and agglomerates and dolerites in the Lower Bowen Series in Queensland (Jack. Geol. Queensland, p. 145).

Volcanic lavas and tuffs in the Greta Coal Measures, in the Illawarra coalfield; lavas of the Canobolas, near Orange; those near Rylstone and in the Murrundi District—all in New South Wales. (David, *op. cit.*, pp. 68-70).

HAWKESBURY SERIES.

Volcanic tuffs at various horizons (David, *op. cit.*, p. 70).

IPSWICH COAL MEASURES.

Volcanic ash-bed in neighborhood of Brisbane (Jack, *op. cit.*, p. 321).

CARBONACEOUS SERIES, VICTORIA.

Mr. A. W. Howitt records tuffaceous beds, *teste* David (*op. cit.*, p. 71).

DESERT SANDSTONE.

Basaltic lavas and tuffaceous beds of insignificant thickness occur in this formation in Queensland (Jack, Geol., Queensland, p. 517).

PRE-EOCENE.

The older basalts of Southern Victoria, previously referred to Miocene, have been shown by Tate and Dennant to be Pre-Eocene (Trans. Roy. Soc., S. Aust., vol. xvii., p. 212, 1893).

EOCENE.

The Eocene flora at Vegetable Creek, in the district of New England, New South Wales, is buried under contemporaneous lava and tuff (David, Geol. Survey, N.S.W., Memoir, 1887, p. 25 *et seq.*).

POST-PLIOCENE.

The newer basalts and ash beds of Victoria; the ash beds of the Mount Gambier area, South Australia (David, Assoc. Adv. Sc., vol. iv., p. 73, *teste* Tate) overlie deposits of the Diprotodon Period.

Section A.

ASTRONOMY, MATHEMATICS, AND PHYSICS.

ADDRESS BY THE PRESIDENT,

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THE PROGRESS OF ASTRONOMICAL PHOTOGRAPHY.

Our section embraces a wide range of subjects, and the honorable position in which you have placed me to-day gives me a recognised right to select a theme for my address from any of these subjects, and to treat it in one of two ways—either to endeavor to add something of my own to the present sum of knowledge, or to endeavor to pass in review what has been done. My impression is that the latter is the better course, and I hope you will be able to agree with me.

I will confine my remarks to a branch of one of our subjects which, within the past twenty years, has done more than anything else to accelerate the progress of our knowledge and to extend our grasp of the grand truths of astronomy. I refer, of course, to the application of photography to the wants of astronomical research. Coming in at first as another possible aid to the observer, it has already shown us that in many cases the observer must stand aside while the sensitive photographic plate takes his place and works with a power of which he is not capable; and I feel sure that in a very few years the observer will be displaced altogether, while his duty will be done by a new sensitive being, not only taking in the visual ray, but also the actinic rays into ultra violet—a being not subject to fatigue, to indigestion, to east winds, to temper, and to bias, but one, above all these weaknesses, calm and unruffled, with all the world shut out, and living only to catch the fleeting rays of light and tell their story.

It has been well said by a very gifted writer¹ that “the invention of the telescope itself does not mark an epoch more distinctly than the admission of the camera to the celestial armory. All the conditions of sidereal research in especial are being rapidly transformed by its co-operation.”

By this new lever the progress of astronomy is being urged forward at a rate which accomplishes more in ten years than was

possible in a hundred years by older methods. Its whole life history covers but fifty-three years, and its infancy and youth were cramped by the want of means of existence and growth; but its latter years have been marked by a vigor which has done so much that I shall have little more than time to mark the stepping-stones in that onward march; to trace the details would take volumes.

Fifty-three years ago photography was in the daguerreotype stage, when it was just possible to get a rough photograph of the moon; forty-three years ago it had reached the collodion stage, and was capable of rendering great aid to astronomy. Its worth had been proved, and the conditions of its successful application to the wants of the astronomer were known, but the enormous value of that power was somehow overlooked. Was it that the innovation was too great to be accepted at once, or that they did not consider the matter sufficiently? If the following record of the slow progress that followed that time and the gradually accelerating progress of the last few years should enlist some other worker into the army of astronomers, it will have done something to add to our knowledge.

It is generally stated that astronomical photography began when, in 1850, Professor Bond succeeded in taking daguerreotypes of the moon with the great 15in. refractor at Harvard College Observatory, but there seems to be no doubt that impressions of the moon were obtained with more or less success some ten years earlier. Professor Henry Draper, of the New York University, writes²:—"The first photograph of the moon was taken by my father, Professor J. W. Draper, M.D., who published notices of them in his quarto work on the forces of organised plants, and in the *Philosophical Magazine*. The specimens were about 1in. in diameter, and were presented to the Lyceum of Natural History of New York. They were taken with a photographic lens of 5in. in aperture, furnished with an eyepiece to increase the magnifying power, the whole mounted on a polar axis and moved by clockwork; the time of exposure was twenty minutes." In September, 1840, he writes:—"There is no difficulty in procuring an impression of the moon by daguerreotype beyond that which arises from her motion." This was not his first attempt to apply photography to astronomical work, for he tried in 1834 to fix the lines of the spectrum. The sensitive surface used was bromide of silver as a coating on paper. The experiment was not a success, but it is mentioned in the *Philosophical Magazine* for 1843, "and in the summer of 1842, simultaneously with M. Becqueret, by using daguerreotype plates, I succeeded, and in the following March sent a drawing of the photograph to the *Philosophical Magazine*, and in 1843 I made photographs of the diffraction spectrum by a grating both by reflection and transmission."

Arago announced to the Academie of Sciences at Paris on the 13th of August, 1839³, the great discovery of Niepce and Daguerre,

and expresses the opinion that it would be possible to make the sun and moon record their own features by photography; and, acting upon this suggestion, Daguerre tried, and failed to get anything more than a very faint impression, from which all detail was absent. In Arago's *Popular Astronomy* there is reproduced a daguerreotype of the sun, taken, as stated on it, on April 2nd, 1845, by MM. Foucalt and Fizeau, but no particulars are given. The long exposure of twenty minutes required to get a daguerreotype of the moon no doubt deterred many who would have tried, and it was only the genius of Bond, coupled with the great refractor, which enabled him to get the first really valuable photograph of the lunar surface. It appears in *Astron. Nachrichten*, No. 1105, that the artists Whipple and Black (of Boston) "for many years before this" had been experimenting whenever they could get the use of the great telescope, and that the earliest successful experiments were made with daguerreotype plates in July, 1850; but the labor and time demanded was so great that he was obliged to put the work aside until he should be able to get improved instrumental appliances. Some of the photographs obtained were taken to England and exhibited at a meeting of the Royal Astronomical Society on May 9th, 1850, again at the meeting of the British Association in September following, and then at the Great Exhibition in 1851; and they were so good that they may be said to have taken the scientific world by storm, but I find at this time no description of what they did show of the moon's surface. The result might have been anticipated. Everybody who could command a telescope from 4in. to 6ft. tried to photograph the moon with such means as he had, and in one case they induced an astronomer, Mr. De La Rue, to become a worker, and his energy and success did very much to promote the study of astronomical photography. I have said that at the time no measure of what was meant by "good" photographs of the moon was given, but four years later we find a measure of the term good applied to them. In the *British Association Report for 1854*, p. 10, the Rev. J. B. Reade, M.A., F.R.S., writes:—"The daguerreotype produced in the Bond refractor possesses a latent sharpness which is difficult to see, but which was brought out by taking a copy of it with a camera. This copy was compared with his own photograph, and he found in both the Mare Crisium with bright surrounding country which separates it from Mare Fecunditatis, and Mare Tranquilitatis, the crater Menelaus, and the ray of light extending from it across the Mare Serenitatis, the semicircular ridge round Mare Imbrium and the unreflective crater Plato,"* so that Bond's picture of the moon must have possessed a large amount of detail.

Mr. Dancer⁵, of Manchester, seems to have been the first in England to follow Bond's lead, and in February, 1852, made some sharp pictures of the moon, using a $4\frac{1}{2}$ in. equatorial. These are

believed to be the first taken in England, and were of such excellence that they would bear examination with a compound microscope with a 3in. objective.

Professor Bond⁶ had not been content with his successful photographs of the moon. He wished to see what could be done with the stars; and, on July 17th, 1850, Mr. Whipple, under his direction, placed a daguerreotype plate in the focus of the great refractor and obtained the first known stellar photograph—a picture of Alpha Lyrae. The time it took is not given, but it is stated⁷ that no image of the pole star could be obtained, no matter how long the exposure was continued, but an elongated image of the double star Castor was obtained before the experiments were given up. At first it seems strange that a picture of the moon could be taken with comparative ease, while bright stars, which we know are capable of recording themselves in less than one-tenth of the time required for the moon, required a much longer exposure; and in some cases would not do it at all; but it is obvious that the reason of this is to be found in the imperfection of the clockwork, which, instead of keeping the star image fixed on one spot on the plate, causes it to wander about that point until the light was too diffused to produce the desired effect.

In 1858⁸ Dr. Luther, of Königsberg, showed Mr. De La Rue the daguerreotype of the total eclipse of 1851, which had been taken by Dr. Busch with the Königsberg heliometer. Considering the state of photography at that time the successful result was remarkable, when due allowance is made for the uncertainty then existing as to the brilliance of the prominences. Towards the end of 1852 Mr. De La Rue⁹ took some photographs with the then new collodion process on glass. He used his 13in. metallic reflector without clockwork, and naturally met with considerable difficulty, although the time of exposure, ten to thirty seconds, was very short for those days. The work required two persons, and was very tiring, owing to the number of failures. Motion was at first given to the telescope by means of the tangent screw, and then better results were obtained by putting the sensitive plate in a slide and moving it to follow the moon's apparent motion. This was done by hand, and the amount of motion was determined by looking at a crater through the transparent collodion film, and keeping it bisected by cross wires attached to the back of the plate. Rough as these contrivances seem when measured by modern appliances, Mr. De La Rue succeeded in making some excellent photographs, but, owing to the difficulties, he came to the conclusion to discontinue the work until he should get clockwork to move the reflector.

These photographs were exhibited at a meeting of the Royal Astronomical Society in 1853; they were $1\frac{1}{2}$ in. in diameter, and were considered very good indeed.

It appears¹⁰ that at this time (1853) the possibility of using photography to delineate the surface of the moon became a burn-

ing question with the British Association Committee for the survey of the physical aspect of the moon, and one of the members, Mr. John Phillips, M.A., F.R.A.S., determined to try what he could do with his own telescope, which had a 6½ in. Cooke objective and 11 ft. focus. Though, in part, prepared at the beginning of the year, he was not able to make an actual beginning until July, and on 15th and 18th, assisted by Mr. Bates, he obtained some photographs, which were exhibited at the British Association meeting September, 1853. The committee thought that they proved beyond a doubt that the research is of a useful and practicable kind, and may be followed up by better things. The images were on collodion plates, and measured 1.2 in. in diameter and were enlarged by an eyepiece in the telescope to 2 in., and the time of exposure was thirty seconds.

In 1854 the Photographic Society of Liverpool¹¹, being anxious to show moon photographs with others of more general character to the meeting of the British Association that year, appointed a committee of the members, of whom Mr. J. Hartnup, the astronomer, was one, to make some lunar photographs for exhibition at the British Association meeting in Liverpool in September of that year.¹²

The telescope used had an objective 8 in. diameter and 12½ ft. focal length. Mr. Hartnup, of course, did the work, and got some very good photographs, of which, it is reported, the photographs of the moon shown at the meeting of the British Association at Liverpool were said to have "outstripped all other attempts made elsewhere," and in the report of the council of the Royal Astronomical Society, February 10th, 1854, it is said that "the beautiful art of photography seems likely to be of much utility in conducing to a more accurate knowledge of the physical condition of celestial bodies."

At the Royal Astronomical Society meeting, June 9th, 1854, Mr. Hartnup exhibited ten collodion pictures of the moon, 1.35 in. in diameter, and ten enlarged copies, some of which were 4½ in. in diameter. These were all taken during May, 1854.

When thrown upon the screen and made 8 ft. in diameter they were much admired by the astronomers present, and the president alluded to the gratifying progress of Mr. Hartnup's labors in connection with this interesting subject. The report of the Royal Astronomical Society for 1854 goes on to say that Sir John Herschel strongly recommended¹³, under date April 24th, 1854¹⁴, the daily photographic representation of sun spots, and the Kew Committee took the matter up and moved the council of the Royal Society, who decided that the work should be undertaken at Kew, and placed in Mr. De La Rue's hands the duty of carrying out the work for the council. Ross, the optician, made the photo-heliograph, which had an objective 3.4 in. diameter, a focus of 50 in., and an enlarging lens, which made the sun's image 12 in. in diameter. While this was going on an amateur, the Rev. J. B. Reade, M.A.,

F.R.A.S., whom I have already quoted, was very busy trying to take photographs with what must have been in those days a very large instrument. The Craigh telescope, at Wandsworth, which he used, had a diameter of 2ft. and a focal length of 77ft. It is not stated whether it was a refractor, but "the true photogenic focus was difficult to find," and he goes on to say, "that so large an object glass worked by hand should do so much with the stars is far from discreditable."¹⁵ He then speaks of reworking the surfaces of the object glass, which seems to leave no doubt that it was not a reflector, which has one surface only. With such a long focus the moon's image should be nearly 8in. in diameter; the time of exposure for a collodion picture of the moon was thirty-five seconds. This telescope was not equatorially mounted, and the moon's apparent motion when near the meridian was counteracted by a "screw motion given to the eye end of the telescope"; the rate was guided by looking through the collodion at a crater kept on cross wires; from a negative taken on September 6th, 1854, a negative 9in. in diameter was made, which was compared with one taken by Bond at Harvard Observatory, and Mr. Reade adds, "in this photograph all the more important features of the moon's surface will be discovered by those who are familiar with their telescopic appearance." I have already quoted his comparison of his photograph with the Bond photograph.

In 1857 Professor Henry Draper¹⁶, after seeing Lord Rosse's great reflector, returned to America with his mind made up to construct a large reflector and use it for astronomical photography. He made a metallic reflector 15½in. diameter and 12ft. focus, but soon discarded it for a silvered glass one of same size and 12ft. 6in. focus.¹⁷ He made 1,500 photographs of the moon with it, of which the best was made September 3rd, 1863, and was enlarged to 3ft., the original being 1¼in. diameter. In 1857 Bond¹⁸, having supplied the driving clock of the equatorial with the spring governor which he had invented, again turned his attention to photography, and by the aid of the more rapid collodion plates took photographs of stars of various magnitudes up to the sixth; the brighter star of Zeta Ursæ Majoris recorded itself in two seconds and the companion in eight seconds. Measures were made of these, and in this early stage it was found that the probable error of a single measure of the distance between them was only $\pm 0.12''$. Star pictures were made soon afterwards by Mr. De La Rue and Mr. Rutherford, at the meeting of the Royal Astronomical Society on November 13th, 1857. Mr. Airy, the Astronomer Royal, exhibited Bond's photographs of this double star, Zeta Ursæ Majoris, and used these memorable words—"This photograph marks a step of very great importance which has been made, of which either as regards the self-delineation of clusters of stars, nebulae, and planets, or as regards the self-delineation of observations, it is impossible at present to estimate the value." Mr. Bond had, in 1857, obtained

photographs of the bright stars Castor and Vega, and now with more sensitive collodion he was able to take the companion of Zeta Ursæ Majoris, which is fifth magnitude and emerald green in color, so would photograph in normal conditions. The time required was eight seconds. Now the Brothers Henry photograph such a star with a 13in. star camera in one-fifth of a second. Bond's objective reduced to 13in. would take 10·7' to photograph this star, and therefore fifty-three and a half times longer than it does now.

Hartnup, in Liverpool, 1864, took 124 times longer for the moon than it does in Sydney to-day.

Mr. De La Rue's¹⁹ work in 1852 has already been mentioned, and the photographs then taken without clock movement were so promising that he determined to have a proper clock. This was not finished till 1857, and he then devoted his whole energy and his observatory to the study and practice of astronomical photography, and everyone is aware of his pre-eminent success—success eclipsing all that had been done before; and even in the present day his work must still be classed as good, but not equal to the best modern efforts.

At the British Association, in September, 1859, he exhibited two original negatives of the moon, which would bear considerable magnifying power—two enlargements from these 8in. in diameter, other enlargements $3\frac{1}{2}$ in. diameter; photographs of Jupiter, showing his belts and satellites; and one of the Moon with Saturn near the limb taken in fifteen seconds.

From the same source I learn that experiments in lunar photography were made by Lord Rosse with his 6ft. reflector. Having no clock motion for the telescope, he applied to it a sliding plate holder of the kind used by De La Rue in his first experiments, but this is said not to have met all the exigencies of the case. The telescope was wanted for other purposes, and from the fact that no photographs with the great reflector were published, it is probable they were not so good as it was hoped they would be. In his best photographs of the moon²⁰ De La Rue claimed to have recorded in a picture of the moon $1\frac{1}{10}$ in. diameter details so small that any subsequent change over a space measuring two miles each way must be detected, and claimed²¹ to be able, with best weather and chemicals, to get a photograph of dark parts of crescent moon in from twenty to thirty seconds which would show all the parts visible near the dark limb.

Having made a new driving clock in 1857, Bond devoted the great refractor at Harvard College to a series of experiments, which lasted to 1858²², making photographs of stars with various apertures from the full 15in. down to lin., to ascertain the possibility of classifying the stars by their photographic images on the plate, which, being suitable for accurate measurement, he

deemed more satisfactory than the method of eye estimates in common use; and he came to the conclusion that the photographic magnitudes of stars increase by equal areas for equal increases in time of exposure, so proving that the photographic method of determining star magnitudes proceeded on the same principle as eye estimates, and anticipating by twenty-six years the same work which has been gone over by several astronomers for the star charting now in progress.²³ Professor Pritchard, however, came to another conclusion, viz., that the area of the star image varies as the square root of the time of exposure.

The photo-heliograph²⁴, which had been set up at Kew on the earnest recommendation of Sir John Herschel, already referred to, was completed at the end of February, and work on the sun was begun with it on March 1st, 1858, but at first was not continuous owing to the necessity for modifications in order to make the exposure short enough. This was ultimately accomplished by a shutter with a slit in it working in the focus of the objective.

About 1860 Mr. De La Rue²⁵ turned his attention to the possibility of photographing the details of sun spots with his reflector, and exhibited some on a scale of 3ft. to the sun's diameter. They were not so good as he hoped to make them, but the cause he thought was in the secondary magnifier. They were taken in one-twentieth of a second. It does not appear that they ever came to perfection; indeed it is well known now that the chief difficulty is vibration in the atmosphere, which is seldom absent; but he pursued the subject, and we are told in 1863²⁶ that he had exhibited some photographs of sun spots on the enormous scale of 13ft. for the sun's diameter, and also some prints from them produced by Herr Pretsche's process (untouched by the graver).

Meantime this enthusiast, whose ability and energy for many years led the way in the application of photography to astronomy, was busy photographing star clusters with his reflector, but he found it better to use a large portrait lens, which gave very encouraging results. He remarks "the difficulty does not consist in fixing the images of the stars, but in finding the images when they are imprinted, for they are no bigger than the specks common to the best collodion."

At this time²⁷ some curiosity existed as to the possibility of photographing comets. "I tried" writes De La Rue, "with my reflector, on the appearance of Donati's comet in 1858, several times, without success, and on the appearance of the comet of the present year (1861) I tried not only with my telescope, but also with a portrait lens, and with an exposure of fifteen minutes, not seconds, but I failed to get the slightest trace with either." The care in stating the time of exposure was probably due to a report that Mr. Usherwood²⁸, of Walton Common, in Surrey, had secured a photograph of Donati's comet on September 26th, 1858. He used an ordinary portrait lens without equatorial stand, but set

the camera in the ordinary way, and exposed for seven seconds. The picture was about an inch long, and bore enlargement to same extent. Mr. Usherwood used a portrait lens of very short focus on a hill 700ft. high. Still the great difference between his exposure and those of Mr. De La Rue is not easily accounted for, although many accepted Mr. Usherwood's picture as the first one ever made of a comet.

We are told²⁹ that in his photographs of the moon and other objects Mr. De La Rue used a negative collodion containing iodide of cadmium and avoided acetic acid and alcohol in the bath, which he made as neutral as possible. In this way he obtained photographs of full moon, either instantaneously or in five or six seconds, and in its half phase in twenty to thirty seconds.³⁰ Early³¹ in 1859 Mr. De La Rue had the courage to propose, and the ability finally to carry out, the transfer of the Kew photo-heliograph to Spain in 1860, in order to photograph the total eclipse of July 18th in that year. It was a bold experiment, and was crowned with success. In estimating the conditions we must remember that he had no chance of finding out beforehand the time of exposure for red prominences. Two photographs of the totality were secured; each had an exposure of one minute, and each showed the red prominences clearly, and served for ever to set at rest the much vexed question of those days, viz., whether they belonged to the sun or the moon, for the photographs proved definitely that the red prominences belonged to the sun. Mr. De La Rue's station was at Rivabellosa, in Spain, and on the Mediterranean coast of Spain, 240 miles from Rivabellosa, Father Secche³² had set up his observatory, and took photographs with a 9in. refractor on a smaller scale than those taken by Mr. De La Rue, but they fully confirmed the results obtained by the English party—that the prominences belonged to the sun.

In the first photograph taken at Rivabellosa there was to be seen to the east of the sun a totally detached prominence or cloud of curved or boomerang form, and in the second this was partly covered by the advancing limb of the moon, and a fresh lot showed themselves on the other side. The light of the red prominences was estimated to be photographically 180 times brighter than that of the moon.³³

On 27th of February, 1863³⁴, and on 3rd March of the same year, Dr. Huggins led the way in photographing star spectra, and found that when the spectrum of Sirius was caused to fall upon a sensitive collodium surface an intense photographic spectrum of the more refrangible part was obtained; but, "from want of accurate adjustment of the focus, or from the motion of the star not being exactly compensated by the clock movement, or from atmospheric tremors, the spectrum, though tolerably well defined at the edges, presented no indication of lines."

Rutherford³⁵ began his work in lunar photography in 1858 with an equatorial 11½in. aperture and 14ft. focal length. Finding

it impossible to get with this instrument, intended for vision, such perfect photographs as he desired, he tried first a reflector of 13in., but ultimately gave it up, and determined to make an 11½in. objective corrected for photographic purposes. This was not accomplished until December, 1864, and he did not get a satisfactory negative until March 6th, 1865. The construction of this lens was difficult, because its progress could not be tested by the visual image. Mr. Rutherford got over the difficulty by testing it with a spectroscope. With this instrument stars down to ninth magnitude were taken with three minutes' exposure, and the only photograph of the moon taken with it was sharper than any other Mr. Rutherford had ever seen.

It was suggested at the time that photographs of the sky 2° on a side might be taken with it.³⁶

The power to obtain photographs of stars down to the ninth magnitude with such a small aperture and an exposure of three minutes promises to develop and increase the application of photography to the mapping of the heavens, and in some measure to realise the hopes that have so long been deferred and disappointed.

On January 11th, 1869, M. Janssen³⁷ presented to the Academie of Sciences a short note pointing out that it was possible to isolate any part of a spectrum by placing a second slit near the eyepiece—an idea which underlies some of the most remarkable results of the present day, but it lay dormant until 1892.

In 1871 Dr. Draper³⁸ completed a 28in. silvered-glass reflector, made for the purpose of photographing star spectra, and in May, 1872, and again in August, he photographed the spectrum of Vega, showing four strong lines. Dr. Huggins, as we have seen, photographed the spectrum of Sirius on a collodion plate in 1863. In 1870³⁹ Professor C. A. Young succeeded in photographing the prominences of the sun. Negatives were made showing the solar disc on a scale 2in. in diameter, which represented clearly the general form of the prominences, but the telescope was too small for good definition, and the work was given up. The light of the hydrogen line Y was used because more actinic than K. They were taken with an open slit on the spectroscope.

In 1872 Mr. Ellery photographed the moon with the great reflector at Melbourne with marked success, and produced the finest photographs that had been seen up to that time.

In 1873-4 many persons urged that photography should be applied to the transit of Venus, and Sir G. B. Airy, after some hesitation, adopted this as an auxiliary method, and in 1874 it was used by the majority of parties sent out as a means of determining the position of Venus on the sun. It did not prove so successful as it was hoped it would, but on many of the photographs taken in New South Wales the ring of light surrounding the planet at and near the sun's limb was clearly recorded and shown to be brighter than the sun itself by the greater deposit of silver which

it produced. In 1874 Dr. Huggins tried to photograph the spectra of planetary nebulae, but without success, the instrument at his command not being large enough.

The year 1876 was an important epoch in the application of photography to the astronomer's needs, for in that year gelatine dry plates, which had been first put on the market in 1871, attained such perfection that Dr. Huggins, after an extensive series of tests comparing them with the best collodion films, gave the preference to the new-fashioned dry plates, and therefore exposures could be continued for hours, and even days, instead of a few minutes, the possible limit for collodion plates. Dr. Huggins used the new plates to record the spectrum of Vega on December 21st that year; it contained seven strong lines, all of them strongly shaded at the sides, and two of them coinciding with the well-known lines of hydrogen. Thus another advance was made; the greatest number of lines previously photographed was four.

Dr. H. Draper⁴⁰ in 1877 announced his discovery of oxygen in the sun in a paper read before the American Philosophical Society. On July 20th he found, by photographing the spectrum, a number of bright lines in the solar spectrum coinciding with lines of oxygen, and said "We can no longer regard the solar spectrum as a continuous spectrum with certain rays absorbed by a layer of ignited metallic vapors, but as having also bright lines and bands superposed on the background of the spectrum."

In 1877 came another important advance. M. Janssen succeeded⁴¹ in photographing the sun, with extraordinary results. The images were 12in. in diameter, and displayed remarkably sharp details of the sun spots, willow leaves, rice grains, and faculae. But the most remarkable result obtained—and which was exclusively due to the improved photographic method—the whole photosphere was covered with a fine granulation of very varied forms, dimensions, and arrangements; but the most remarkable of all was the discovery of a fine photospheric network—"Reseau photosperique." The forms generally have rounded contours, but some are rectilinear and others polygonal; and in the intervals of this network the rice grains are distributed and definitely bounded, and in their interior (*i.e.*, the net spaces) the "granules are half obliterated, drawn out, and confused." This great step in advance was obtained chiefly by improving the old flashing shutter and reducing the time of exposure to $\frac{1}{30000}$ th part of a second.

In 1878⁴² Dr. H. Draper succeeded in getting very perfect photographs of the solar eclipse in July of that year, showing that the spectrum of the corona was similar to that of the sun—in other words, the corona must be sunlight reflected from matter in the neighborhood of the sun, and, if that accounts for the whole of its light, then it would not be possible to photograph it apart from the sun. The photograph was confirmed by the visual observations of Professors Barker and Morton, two of Dr. Draper's party.

In a paper read before the Royal Society on December 18th, 1879, Dr. Huggins gives details of his work in photographing star spectra since he began his new and successful process in 1876, when he obtained seven lines in the photograph of the spectrum of Vega. He used a prism of Iceland spar and lenses of quartz. With this arrangement definition was so good that he could count seven lines between H and K in the solar spectrum, and could photograph star spectra from G to O in the ultra violet. He made it a practice to set the slit always to the same width ($\frac{1}{360}$ of an inch), and he used gelatine dry plates because they were more sensitive and could be exposed as long as he desired.⁴³ He had photographed the spectra of Sirius, Vega, Arcturus, Beta Pegasi, Betelgeux, Capella, Alpha Hercules, Rigel, and Alpha Pegasi: also Jupiter, Venus, Mars, and portions of the moon. The planetary spectra show no sensible modification in the violet and ultra violet parts such as would result from atmosphere on any of them. Six of the stars belonged to the "white" class. In this paper Dr. Huggins states that the spectroscope aided by photography might be made to afford valuable information in the study of variable stars—a prophecy which we shall find was fulfilled a few years later—and that it was evident the period of the sun's rotation could be determined by spectroscopic observations on each side of it. These brilliant results had not been attained without a determined battle with the difficulties in instruments and appliances then in use, and an amount of energy had to be expended in that way that would have borne grand fruit had instrument makers been equal to the demand of science. An indication of what had to be gone through is found in the fact that, in order to get the equatorial to follow the stars, it had been necessary to get made no less⁴⁴ than seven different driving clocks.

In July, 1881, Professor Vogel⁴⁵ announced his important work and complete success in photographing the spectra of rarefied hydrogen, which gave a spectrum almost exactly coinciding with Dr. Huggins's ultra violet spectra of white stars.

Dr. H. Draper⁴⁶, on March 11th, 1881, photographed the nebula in Orion, and one of the stars shown in it is of 14.7 magnitude, which is about the limit of what can be seen with a telescope of that size. So he had just brought the star camera to record as much as could be seen, and he would doubtless, had he lived a few years more, have done what has since been done, viz., photograph stars far beyond the range of vision: it was done soon after his death by A. A. Comman and others.

Between 1868 and 1881 improvement in spectra photographing apparatus had been very great, but there had in the interval been no comet bright enough to try the experiment of photographing its spectrum, and Dr. Huggins⁴⁷ eagerly seized the opportunity on the 24th June, and succeeded in getting a fine photograph of the spectrum of bright comet *b* of 1881. The photograph was the result of an exposure of one hour, and on another bright night he

got one with one and a half hour's exposure. Two superposed spectra are shown—one a continuous spectrum of reflected sunlight extending from F to a little beyond H; the other two sets of bright lines from the comet's own light, with a suspicion of the presence of a third set of lines.

Dr. Henry Draper⁴⁸ succeeded in photographing the comet *b* in Aurigæ on June 24th, 1881, in one exposure of two hours forty-two minutes; the comet is shown with tail about 10° long, and several stars showing through it. He tried to get its spectrum first, with a direct vision spectroscope and an exposure of eighty-three minutes, which gave a spectrum of nucleus coma and tail, then used a two-prism spectroscope, with three exposures, 180, 196, and 228 minutes. There is in the spectrum a heavy band above H, which is divisible into lines between G and *h*, and another between *h* and H.

M. Janssen⁴⁹ also secured a photograph of comet *b* on July 1881. He used a telescope half a metre in aperture and 1.60m. in focal length. The photograph was exposed for thirty minutes, and shows a tail $2\frac{1}{2}^\circ$ long, in which were some rectilinear rays, which were revealed by the camera, but not visible. It will be remembered that, seven days before, Dr. H. Draper, using a larger telescope and more than five times the exposure, found the tail on his photograph 10° long.

On the 7th March, 1882, Dr. Huggins⁵⁰ succeeded in taking a photograph of the spectrum of the great nebula in Orion. He used the 18in. reflector metallic speculum, and the exposure was limited by clouds to forty-five minutes. The photograph shows a spectrum extending from a little below F to beyond M in the ultra violet; there are five bright lines as well as a narrower continuous spectrum, which Dr. Huggins thought was due to stellar light. It may be mentioned that only four bright lines had been seen by the eye.

Dr. Draper⁵¹, of New York, had been for eighteen months taking photographs of the nebula in Orion—to see, first, if it was changing, and, second, for the spectra of the various parts. In March, 1882, he made two good photographs with two hours' exposure. On these he saw four of Dr. Huggins' lines, but not the fifth ($\lambda 3730$). In one of the plates is the spectrum of a tenth-magnitude star—the smallest star that had so far had its spectrum photographed.

On May 31st, 1882, Dr. Huggins⁵² obtained a photograph of the spectrum of comet (Wells). It showed an essential difference between the spectrum of this comet and others. The nucleus shows a distinct spectrum, in which five brighter parts are seen, probably due to bright lines. The spectrum extends from F to a little beyond H, and no Fraunhofer lines can be seen in it.

Professor Schuster's photographs of the eclipse of May 17th, 1882, show the coronal light is very strong from about G to H;

and Dr. Huggins⁵³ thought that it would be possible, by using absorbing media, to keep out the other rays, and that it would be possible to photograph the corona by the part between G and H. The importance of this will be seen when it is remembered that the eclipsed sun is only visible about eight days in a century, and then only from small and inconvenient areas of the earth's surface, and even this small chance is again limited by cloud and possibly inaccessible positions on the earth's surface. The possibility of making an artificial eclipse such that the sun's surroundings could be photographed at any time was a problem worth working at, and Dr. Huggins⁵⁴, with characteristic energy, threw himself into it, and succeeded by using absorbing media in getting faint but unmistakable photographs of the corona; the available media were insufficient for better results.

In 1866 and 1868⁵⁵ he had tried by the same method to see the prominences, but met with only partial success for want of more suitable media. He had, however, in 1867⁵⁶, by means of absorbing media, insulated the spectra of different parts of the sun's surface, such as the spots and the *umbra* of spots. The photographs of the corona taken by Dr. Huggins about the time of the eclipse of May 17th, 1868, were examined by Captain Abney, who said that "not only were the general features in them the same as in those taken by himself in the actual eclipse in Egypt, but also that details, such as rifts and streamers, have the same form and position," but the absorbing media were not satisfactory, and he subsequently used a reflecting telescope and chloride⁵⁷ of silver as a sensitive surface, which is sensitive only to violet rays. With this some success was attained, but not enough to satisfy Dr. Huggins, and the work was given up, although he felt "that problems of the highest interest in the physics of the sun are doubtless connected with the varying forms of coronal light, which only seem to admit of solution on the condition of its being possible to study the corona continuously." From fifty photographs of the corona which Dr. Huggins had taken in this way during May, Mr. Wesley was able to prepare a number of drawings of the corona.

In 1883 Professor Pickering⁵⁸ designed a star camera with the object of making regular comparisons of star magnitudes. It was so arranged that the whole heavens from 30° south to 60° north and over three hours of right ascension could be photographed on one plate measuring 6in. x 8in., which was divided into six parts or pictures, all of which could be taken in eighteen minutes. The great facility such an arrangement affords for comparing star magnitudes is obvious, and the result has fully justified the time given to it.

For some years before his death (in 1882) Dr. H. Draper had devoted himself to the study of stellar spectra, and his death for a time put an end to this important work, but it was subsequently

(1883) taken up by Professor Pickering at Harvard College, and Mrs. Draper was induced to provide the money for this work as a memorial to her husband—one of the noblest monuments ever raised over a scientific man.

In May, 1884, MM. Henry Brothers were making photographic experiments to test the accuracy of their method of measuring double stars from photographs, and in September the same year they had succeeded in photographing the small stars of the ecliptic. The difficulty of recording the positions of these stars in the old laborious way had induced them to try to photograph this part of the heavens in order to avoid the labor of recording them by the eye and hand. The method when completed not only recorded the stars which were required in the search for small planets, but actually made it unnecessary to look for the planets through a telescope, because they show themselves amongst the stars by making a trail instead of a round spot, and this was done with the experimental $6\frac{1}{2}$ in. star camera. This success was so satisfactory that they began at once to make an objective of $13\frac{1}{4}$ in. for this special purpose, and expected to be able to photograph stars to the twelfth magnitude.

With this larger star camera, on November 16th. 1885, they found in taking photographs of the Pleiades a hitherto unknown nebula about the star *Mia*. The star camera had literally called it from darkness to light.

In October, 1884, MM. Henry⁵⁰ had got the new 13 in. star camera fairly at work. They had taken a photograph of the cluster of stars in Hercules, giving it fifty minutes' exposure, and found 550 stars of from seventh to twelfth magnitude. In another place with sixty minutes' exposure on a surface five degrees square they counted 2,790 stars between sixth and fourteenth magnitudes, and traces of fifteenth magnitude stars, whose diameter was only $\frac{1}{1000}$ in., and Admiral Mouchez, in referring to this work, said they had gone so far as to secure images of a few stars of seventeenth magnitude, "and such stars, without doubt, have never been seen before"⁵¹—they are beyond the reach of any telescope.

Their experiments proved that they could photograph a star of the first magnitude in $\frac{1}{2000}$ th part of a second, one of fifth in one-fifth of a second, one of sixth in half a second, one of tenth in fifty seconds, and stars of sixteenth magnitude, only just visible in the largest telescopes, in eighty-three minutes, and their experiments led them to estimate the whole number of stars visible in Sir John Herschel's telescope which they could photograph as twenty-two and a half millions. Herschel, as the result of many counts in various parts of the sky, had estimated the number he could have seen in the whole sky, if he spent forty-five years in doing it, as twenty and a half millions.

It is obvious that a photograph taken now and showing accurately the positions of the stars will, if compared by super-

position with another taken on the same scale a few years hence, point out at once any change of position due to proper motion, &c.

When, on December 13th, 1885, the new star (Nova Orionis) was discovered by Mr. Gore⁶⁰, Professor Pickering's photographic star charts, showing all the stars, became at once available, and one taken on November 9th, 1885, affords unmistakable evidence that this star was then much fainter than it was five weeks later when he discovered it.

On the 15th March, 1885⁶¹, a very brilliant aurora at Christiana was photographed by Mr. Sophus Tromholt. He used Viogtlander's euroscopic No. 1 lens and rapid dry plates. Exposure of from two to four minutes gave nothing, but one of eight and a half minutes showed the light in the sky, with buildings outlined on it. This was the first time an aurora had been photographed.

On May 11th, 1885, Admiral Mouchez⁶² at a meeting of the Academie of Sciences, at Paris, stated the first experiment made by MM. Paul and Prosper Henry with a camera, objective $6\frac{1}{4}$ in. diameter, had proved so successful that a new instrument had been constructed, which had a star camera with objective of $13\frac{1}{4}$ in., and another telescope for a pointer alongside of it for watching the clock motion, and although it was not quite complete it had already yielded some remarkable results, and seemed to solve the question how to use photography in mapping the heavens, taking in stars down to the fourteenth or fifteenth magnitude. . . As we have already seen, it was thought just twenty years before this that Rutherford's star camera had solved this question, and so it had; but the astronomical world was not ready for such a gigantic step forward, and therefore it had to wait until the general progress in astronomical photography had cleared the way for its adoption in recording star positions.

It was found by Professor Pickering in 1885 that photographs of star spectra can be obtained by simply placing a large prism on the outside of the object glass of the telescope⁶³, and he adopted this method with a star camera of short focus and thus in an exposure of five minutes the spectra of all stars down to the sixth magnitude, and included in an area 10° square, are recorded; and arrangements have been made to photograph in this way the spectra of all stars down to the sixth magnitude, and it is found that the spectra of stars down to the tenth magnitude can in the same way be got in one hour.

In 1886 Professor Harkness⁶⁴ proposed to get over the difficulty caused by the heat of the sun on transit instruments by arranging it so that a sensitive plate could be put near the wires, and a momentary flash of light let in just enough to photograph the sun and show the wires.

Several others had proposed to photograph the stars in transit, but nothing important has yet been done in this direction; but I

hope to show you presently that I have the design ready by which meridian transit work will be done by photography in a far more exact way than it can be done by the eye.

Professor Pritchard, of Oxford⁶⁵, was the first to apply the photographic method to the determination of stellar parallax. He conceived the idea in May, 1886, put it to the test of experiment by determining the parallax of 61 Cygni, not with the object of determining the distance of a star so well known, but for the purpose of putting his novel method to a crucial test. He selected a star the parallax of which had been so well determined that there was a definite value before he began; probably the parallax of this star was better established than that of any other. His great success is well known, and the accuracy of the method so great, that a most satisfactory value of the parallax was obtained coming close to the mean of the four best values previously determined by older methods.

The Oxford value is:—

61 ¹ Cygni	0.438
61 ² Cygni	0.441
<hr/>	
Anwer's, value	0.348
Bessel's, value	0.564
Ball, value	0.468
Asaph Hall, value	0.261
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Mean	0.410
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The professor determined the parallax of thirty stars conveniently situated from Oxford of first and second magnitudes; and collecting those determined by Gill and Elkin of stars of the first magnitude, he was able to give in his "Researches into the History of Stellar Parallax" a list of ninety-three bright stars, the distances of which have been recently measured. This list includes the majority of the bright stars, and from this he deduced that the average parallax of first magnitude stars is 0.89" and of second magnitude 0.056". There are considerable deviations from the mean in both classes; but the fact remains that the first magnitude stars are nearer to us than the second, and both very much nearer than the faint stars with which they were compared to determine their distances.

On October 24th, 1886, Dr. Isaac Roberts, who had been so successful in photographing faint objects, turned his telescope on the nebula about M4, and found that it was much more extensive than had been supposed; many branchings seemed to form a background for the whole cluster of the Pleiades.

In April, 1887, a conference of fifty-four astronomers from all parts of the world met at Paris, and agreed upon a scheme in which eighteen of them undertook to carry out the work. All were to use star cameras of the same size and focal length and take two

sets of photographs—one including stars down to the fourteenth magnitude, the other set to take stars to the eleventh magnitude only. These are to be measured and catalogued for reference, and the heavens have been divided into eighteen portions as nearly equal as possible.

On March 15th, 1888, Professor Vogel⁶⁶ announced in a paper read before the Royal Prussian Academy that he had found in taking photographs of the spectra of stars that the vibrations of our atmosphere, which are so exceedingly troublesome to the eye, rendering it oftentimes impossible to make a measure, do not affect the definition of a photograph of the spectrum at all.

Dr. Huggins, as we have seen, was the first to use the spectro-scope to determine the motion of stars in the line of sight, and Professor Vogel⁶⁷ was the first to apply photography to recording spectra in order to determine star motions in the line of sight. For this purpose he used the 12in. equatorial at Potsdam to carry the very fine spectrograph which he had designed. The work was begun in September, 1888, and by May, 1891, all the stars in the northern heavens, fifty-one in all, bright enough for the purpose had been examined with this instrument, and their velocities in the line of sight accurately determined.

On December 29th, 1888, Dr. Isaac Roberts succeeded in making a very fine photograph of the great nebula in Andromeda, which is a startling revelation of its extent and complex character.

At a meeting of the Royal Astronomical Society, March 8th, 1889, Captain Abney⁶⁸, the highest authority, replied, in answer to a question, that "I have made experiments and can say distinctly there is, as far as I know, no light so feeble that an accumulation of it will not give an image upon a photographic plate." And not long since we were told, upon other authority, that a good photograph of a dark interior of a building has been taken and required seven whole days' exposure. There seems then no reason why exposures should not be continued night after night, reaching fainter and fainter lights.

Professor Pickering⁶⁹ had a startling report to make in the fact that the work of photographing the spectra of all stars down to the sixth magnitude, between 25° south declination and the North Pole, was completed in May, 1889, and that it contained 10,800 stars and 28,000 spectra; that in practice it was found that planetary spectra are readily distinguished from those of stars, and it had been decided to take the Bache telescope to Arequipa, and continue this survey to the South Pole, and Mrs. Draper has enlarged her original gift in order to determine the spectra of all stars down to the tenth magnitude; the original 28in. reflector made by Dr. Draper for star spectrum work is to be used. In 1888 and 1889 Dr. Huggins secured photographs of the spectra of the nebula in Orion, confirming his results obtained in 1882, only altering the wave length of one line from 3,730 to 3,724, and

revealing a number of additional lines in the ultra violet as well as in the continuous spectrum, and he considered it probable that these features indicate a physical condition at or near the beginning of the cycle of their celestial evolution.

The white stars are distinguished by the number of their spectra lines in the ultra violet, which indicate a greater intensity of temperature and point to a comparatively recent formation from the condensation of highly heated matter; as these stars radiate their heat they change color, the red stars being the coldest we know.

In 1890 the southern part of the Milky Way was photographed at Sydney with a 6in. protrait lens, special attention being given to to the parts that are dark to the eye, and the camera revealed a multitude of stars in them, especially in the Coalsack in Crux, in which the stars seemed about as numerous as in the parts about, and their distinctive grouping has such a strong family likeness to the parts of the Milky Way near them that there seems to be no reason to doubt they belong to the same system.

In August, 1889, Professor Pickering⁷⁰ pointed out that a star camera with double objective 24in. in diameter would be a powerful aid to astronomical photography, and Miss C. W. Bruce, of New York, came forward and gave 50,000 dollars for the purpose of making this great instrument for photographing star spectra. On January 8th, 1890, Professor Pickering⁷¹ announced that one of the results of the work done under the Draper Memorial was the discovery of a new class of binary stars, whose components are far too close to be seen by any other method.

It was first noticed that the conspicuous lines in the star were sometimes double, and an extended series of photographs revealed the fact that the duplication came at intervals of fifty-two days, and this is completely accounted for if one assumes the existence of two stars with similar spectra very close together and revolving round each other in a plane passing nearly through the sun; the doubling of the line is, of course, caused by the fact that the star is at one time moving towards us and at another away from us. A similar case was discovered by Miss A. C. Maury, who, when examining the photographed spectra of Beta Aurigæ on forty-seven photographs, found that the star line doubled periodically like those in Zeta Ursæ Majoris, but at shorter intervals; in fact, that one of the stars goes round the other in two days. It is a startling discovery to find binary systems of this kind so very different from any previously known, and I think there can be no doubt that this fact would have been hidden for ages to come but for photography, because until the discovery was made there was no apparent reason for every day examination of the spectrum of a star; indeed, until then, when the lines were once carefully measured they were put aside by the observer as finished and definite records of the star's spectrum. These first results indicate that the components of Beta Aurigæ are separated by an angular interval of

only 0.004", a quantity so small that twenty years ago no one ever dreamt of being able to measure it.

At the meeting of the Royal Prussian Academy of Science on November 28th, 1889, Professor Vogel⁷² stated that he had photographed the spectrum of Algol six times—three in the winter of 1888-9 and three times in November, 1889—and that he found before the minimum the lines in the spectrum of Algol are displaced towards the red, showing that the star is receding, and after the minimum they are displaced towards the violet, showing approaching motion, and these facts can only be accounted for by the theory that Algol is associated with a dark star, and that the two revolve in the plane of the line of sight round the common centre of gravity once in 68.8 hours. At minimum the dark star intercepts some of the light by being on this side of Algol, and the photographed spectrum further justified the conclusion that the diameter of the larger body was 1,074,000 miles; of the smaller one, 840,000 miles; the distance between them, 3,269,000 miles; the speed of Algol in its orbit, 27 miles per second; and of the dark one, 56 miles per second, and that the system was approaching the earth at rate of 2 miles per second.

In March, 1891, it was announced that Professor Rowland⁷³ has accurately photographed the whole of the solar spectrum from D down to the extreme ultra violet, by means of concave gratings. It is the most perfect map of the solar spectrum that has ever been made. He has further proved that thirty-six terrestrial elements are certainly present in the solar spectrum, the presence of eight others is doubtful, and fifteen others (including nitrogen, as it shows itself under the electric spark) have not been found in it; and it follows, he thinks, that if the whole earth were heated up to the temperature of the sun its spectrum would resemble very closely the solar spectrum.

On August 7th, 1891, M. Deslandres⁷⁴ exhibited the results he had obtained since May in photographing the bright lines of the solar prominences. The negatives show good reversals of the lines H and K, and the first two lines of the ultra violet hydrogen lines. Professor Hale, of Chicago, also in the middle of April obtained the first reversals of the lines H and K by his method.

The year 1891 will ever be memorable in the annals of astronomy as that in which the great work of a photographic survey of the heavens, which was arranged in 1887 at the Paris conference, was actually begun.⁷⁵

The 24in. star camera, the splendid gift of Miss Bruce, was nearly finished in January, 1893, and it had been decided to use it first at the Boyden Observatory, near Arequipa, under Professor Pickering.

We now come to one of the most surprising results that has marked the application of photography to the wants of the astronomer. Several attempts had been made with more or less success to get a

method by which the sun's surface and surroundings could be regularly studied, but Professor George Hale, guided by what had been done by others, studied and succeeded in working out a new method, which seems to meet all, or nearly all, the requirements. He had completed this work ready to take solar photographs by January 22nd, 1892. He calls the instrument a spectro-heliograph⁷⁶, and by it the solar prominences, faculæ and chromosphere, can be clearly photographed by monochromatic light of the wave length K. It is not necessary here to describe the instrument; it will suffice if I mention the essential points of difference between the spectro-heliograph and an ordinary solar spectroscope. Let us suppose, then, that we have a solar spectroscope. The professor removes the fixed slit, and puts in its place one large enough to take in the whole of the sun and surroundings; this slit can, by suitable machinery, be made to move across the image of the sun. The grating is next so adjusted as to give only the K line of the spectrum. The ordinary eyepiece for viewing the spectrum is next removed, and in its place is fixed another movable slit, which is moved by the same machine as the other one, and at a definite relative rate; all being adjusted, the light of the K line of the spectrum will pass from the grating through the second slit, the use of which is to prevent any side light near the K line from falling on the sensitive surface; to complete the arrangement it is only necessary to put a sensitive plate very close to the second slit. Everything being ready the telescope is uncovered and the slits set in motion. As the first moves across the image of the sun the second moves across the sensitive plate, and any K light passes through it and leaves its record on the plate in a position relative to that on the sun. Thus, practically, a series of very fine lines, sections as it were, across the prominences are recorded side by side until the whole disc is included, and the photosphere and prominences clearly photographed. The operation requires first-rate apparatus and every precaution to ensure success. I will only mention one contrivance. When the slits are adjusted and everything ready to take the photograph, a round disc of metal is put in front of number one slit; it is nearly as large as the image of the sun, and practically makes an eclipse of the brighter parts, leaving only the edge of the sun, the photosphere, and prominences and corona to pass to the spectroscope.⁷⁷ The next point is to secure on the same sensitive plate a photograph of the faculæ and spots. The grating is now set, so that the combined slits only allow the faculæ light to pass. All is then prepared, so that the slits will move across the sun's disc and across the plate. The disc is removed, and the faculæ spots recorded in their true relative positions to the prominences. The apparatus is quite successful, and the professor thinks that, with a modification, he can also photograph the corona; but up to latest reports this has not been successful.

Encouraged by the success of his spectro-heliograph, Professor Hale⁷⁸ has designed for the Yerkes Observatory, Chicago, an improved spectro-heliograph, which will, when finished, carry seventy-two sensitive plates, and automatically record on each of them at any interval that may be desired complete pictures of the spots, faculæ, photosphere, and prominences in true relative position on each plate. All that will be necessary will be to set the telescope, wind up the machinery, and set it to work, the only limits being, first, that it takes two minutes to get a complete picture of the sun; and, second, the number of plates put in the wheel that carries them.

Under the old system it was a good hour's work to record the prominences alone; the new apparatus will do the same work far better in one minute. So far it has not been found impossible to photograph the corona with this apparatus, but experiments are in progress and confidently expected to succeed by which a modified spectro-heliograph will photograph the corona, using only the ultra violet light.

One remarkable result of Professor Hale's spectro-heliograph work is the abundance of faculæ all over the sun from pole to pole, and seen thus they are of curved forms, generally like the figure 3, though spread over the whole surface they are strongest within 40° of the equator north and south, and the greater part of them are invisible to the eye, and in Professor's Hale's opinion they "are not to be confused with Janssen's reseau photosperique." Janssen, in 1869, in a paper read before the British Association meeting at Exeter, pointed out that it was possible to isolate any particular line in the spectrum by using two slits, one being near the eye.

On March 22nd, 1892, a photograph of Swift's comet was taken at the Sydney Observatory, which shows eight narrow rays extending from the head. As these were all quite invisible with the large refractor, it is probable that they were composed of blue or violet light, because if of white light they would have been visible through some of the larger telescopes turned to the comet, if not through the Sydney refractor.

Professor Schaerberle⁷⁹, at Lick Observatory, has recently photographed the corona by the method of absorption introduced by Dr. Huggins, and has obtained satisfactory pictures. He conducted the Lick Expedition to observe the solar eclipse of April 16th, 1893, and in his report he says that the observations and photographs of the eclipse taken confirm his opinion of the structure of the corona, and his photographs of it by Dr. Huggins' method. One of the eclipse pictures shows the dark sun $4\frac{1}{2}$ in. in diameter, and the corona round it covers a plate $18\frac{1}{2}$ in. x $22\frac{1}{2}$ in.

In March and April, 1893, selected parts of the Milky Way were photographed at Sydney with the large star camera and specially sensitive plates, with the results that parts that look nebulous in

the photographs of 1890 are simply masses of stars, that a group that Herschel with his great telescope estimated to contain 200 stars, on the photograph contains 14550, and that a well-defined portion in Sagittarius, which in the 1890 plates contained eighty stars, is now found to contain 1166, or fourteen times as many.

Professor Kapteyn, from his study of photographs taken at the Cape of Good Hope, was able to announce in March, 1893, that stars near the Milky Way and in it are photographically brighter than stars of the same visual magnitude which are at a distance from the Milky Way, and the difference is in proportion to the distance.

The photo-spectrographic method of measuring star motions has already been referred to, but the results have recently, in the hand of Dr. Kempf, given a new and quite independent determination of the rate and direction of the sun's motion in space. Dr. Vogel thought that fifty-one stars were not enough to give the result desired, but as the present apparatus is not powerful enough to determine the motion of any more stars the computation was made, with the result that "the apex of the sun's way" is situated in R.A. 206° and north declination 46° , in the constellation Bootes, and that its motion in that direction is at the rate of eleven and a half miles per second. Many previous attempts have been made to locate the "apex of the sun's way," and they placed it in about R.A. 267° and north declination 31° . This older method affords no means of determining the rate of the sun's motion, unless an assumption was made as to the distances of certain stars, and this made the velocity sixteen miles per second, which does not differ very much from eleven and a half—the value determined from photographs.

As an index of the great accuracy attained at Potsdam in determining motion in the line of sight, it may be mentioned that six photographs of the spectrum Arcturus were taken, from which its motion in the line of sight was determined, and Professor Keeler, using the great Lick telescope on three nights, determined the same quantity by eye measurements, and the two values agree within the tenth of a mile per second.

Professor Keeler, using the great Lick telescope, 36in. in aperture, has determined the motion of several nebulae in the line of sight, and finds values ranging from two to twenty-seven miles per second, and in one case forty miles per second.

In this brief outline of what photography has done, and is doing, much has been omitted for want of space, and in many places the bare facts are given in order of time simply to recall important steps in the progress to your memories. Even in its infancy photography was received kindly by astronomers, and although much was expected from it nobody dreamt what it would be to-day. Sir George Airy, as we have seen, was very much impressed with what he saw, and he felt that a new power in

astronomy was coming to the front; but it is evident that he had no adequate conception what it was going to do for exact records or for descriptive astronomy, or we should have had his great powers devoted to its development. But who could dream in those days that it would be possible now to say, as Professor Pritchard⁸⁰ has said, that in measuring distances of over 2,000 seconds of arc for his photo-parallax experiments he had found the probable error of the distance between two stars so measured to be only one-tenth of a second of arc, and that the camera and spectroscope combined, in Professor Vogel's hands, had separated a double star with a distance of only six-thousandths of a second of arc—a quantity so small that our great telescope will have to be enlarged thirtyfold before we can see it. And Professor Vogel's determination of star motions in the line of sight has, in the opinion of competent persons, shown that attempts to determine the motions of stars in the line of sight without the aid of photography was little better than a waste of time. And Professor Keeler⁸¹, recently in charge of the great Lick telescope, and therefore having full knowledge of the powers of the greatest telescope in the world, writes it has been shown "that visual observation of the spectrum cannot in general compete with photographic methods applied to the same as even much smaller telescopes." Indeed no one can study the results obtained by photography where it has been fully applied without being impressed by the fact that the results are not only far in excess of the amount possible by eye observation, but also of far higher value, and that after a time photography will displace the observer from all astronomical instruments and do much better work than he could ever hope to do with his eyes.

We have to-day passed in hurried review the application of photography to the wants of the astronomer in delineating the moon's surface in the study of her libration; to recording the sun's disc, his spots, faculæ, rice grains, photosphere, red prominences, the corona in actual and in artificial eclipse; to the sun's motion in space; to the sun's rotation periods; to recording that wonderful spectrum with its thousands of lines; to the record of double stars; star charting; star magnitudes; to their classification by quality of light; to recording their almost inconceivable numbers; to star drifting; to star motions in the line of sight; to double stars so close and so remarkable that they can only be recorded by this means; to the record of all the visible stars in the sky for the purpose of detecting changes of magnitude; to the record of the spectrum of every star down to the tenth magnitude; to finding invisible stars and invisible lines in their spectra; in recording the forms and details of nebulæ; to their spectra, to show that the eye does not see all details they present nor their extraordinary extension; its application to recording the form and appearances of comets; to the record of the invisible rays in their tail; to their spectra; to the surface-marking of planets; to their spectra; to

show their satellites, and to record the places of the satellite of Neptune, which it is difficult to see with any telescope, but is photographed easily; to proving that the light round Venus in transit is much brighter than the sunlight itself; to recording the lines in the ultra violet of the spectra of heavenly bodies, lines the existence of which otherwise must have remained for ever unknown to us, because they are invisible.

We have taken only a passing glance at many of the applications of photography, and each of them would repay a careful study. Indeed, the results obtained by means of photography come upon us so fast that one hardly realises their importance. Think for a moment what it means to catch a fleeting ray of light that maybe has for hundreds of years been flying through space with the inconceivable velocity of 180,000 miles per second, to catch and fix it on a photographic plate, and extort from it, not only where it came from, but the physical and chemical condition of the star it came from—whether it be old or young, coming to us or going away, whether the parent star has a bright or dark companion, their dimensions, distance apart, speed in their orbits, and their mass. To extort all this from a wandering ray of light is more wonderful than anything in romance; or, to turn in another direction, the photographic survey of the heavens now in progress, and many plates of which have been taken, will contain a record of at least 3,500 stars for every 1 we can see with the eye.

But grand as the work has been so far, there is yet much to do, and more fields to conquer. It must replace the transit instrument with another more accurate and capable of recording all stars to the tenth or twelfth magnitude. It must find an instrument large enough to record the closest double stars, and such clusters as Omega Centauri. It must write at short intervals the exact forms of nebulae as well as their spectra, showing motion in space, and so record their changes in form as well as their disappearance and appearance that any change will be detected; must make still more accurate records of the magnitudes and spectra of the stars; must sound the star depths in all directions so that photographs of star clusters will show the stars still more accurately, and must find an automatic camera suited to its needs that will keep records of sun, moon, and stars; must picture the moon as perfectly as we can see it, and make it possible to compare minute details month after month, and so detect any changes. No doubt there are difficulties in the way, and even this moderate view of the wants of the future presents many, but they are not insuperable. The army of science is in one respect like the army of war—it is stirred to conquering effort by the difficulties that stand in the way. Given a citadel to be won, and there is always a forlorn hope to win it. Given a glimpse of one of nature's secrets—the photosphere, the prominences, and the corona hidden by the sunlight, except for a moment in each century—and at once you see the army: Huggins,

and Airy, and Young, and Janssen, and Lockyer, and a host of others, all battling with the overpowering light of day in order to win the secret that it hides, winning bit by bit of the difficult way until success is attained.

With such a record of unexpected successes in the past, and so much more that is possible now, it would be folly to attempt to forecast what another ten years will bring forth. Everything points to an enormous increase in the details of the known, and to at least an equally great advance into the unknown. Photographs taken three years ago filled the dark places of the southern Milky Way with stars, and brought at least strong evidence that they have grouping exactly resembling the Milky Way near them—a sort of family likeness which cannot be mistaken. This year some Milky Way spaces taken with the camera of 1890 have been probed by the large star camera, and it may be mentioned, as a measure of the difference of the two instruments, that a well-defined but small space which in the 1890 photograph contains eighty stars, is found in the 1893 photograph to have fourteen times as many stars, or 1166. Now it is possible to-day to get a camera made ten times as powerful as those in use, and there is a talk, and one may say a probability, that in the very near future one will be made a hundred times more powerful. Moreover, the experience of the past has been that the limit in power of the telescope of one age is not the limit of the next. There has been a gradual expansion in the arts, which the astronomer has taken advantage of, and there is every reason to suppose this will continue in the future to an extent of which we can form no estimate. One is tempted to ask—Will the star depths unfold in the same ratio? And the reply comes in the words of the German poet—“Other worlds more billowy, other heights and other depths are coming, are nearing, are at hand; for end there is none to the Universe of God!”

NOTES.

1. Miss Clerke: System of the Stars, p. 23.
2. Nature, vol. x., p. 243. Quarterly Journal Science, vol. i., p. 381.
3. Nature, vol. XLIV., p. 380.
4. Nature, vol. XLII., p. 568; also Observatory, vol. II., p. 13.
5. Chamber's Astronomy, third edition, p. 708.
6. An Investigation into Stellar Photography, vol. xi., North American Academy of Sciences.
7. Astron. Nachrichten, No. 1105.
8. Phil. Trans., 1862, p. 333.
9. British Association Report, 1859, p. 134, *et seq.*; also Astronomical Register, 1883, p. 65.
10. British Association Report, 1853, p. 15.
11. British Association Report, 1854, p. 66; also Astronomical Register, 1863, p. 65.
12. Royal Astronomical Society Monthly Notices, vol. xv., p. 132.
13. Royal Astronomical Society Monthly Notices, vol. xv., pp. 140 and 158.
14. This was the second time, see Cape Observations, p. 435, foot note.
15. British Association Report, 1854, p. 10.
16. Quarterly Journal of Science, 1864, pp. 381 and 384.
17. Quarterly Journal of Science, 1864, p. 382.

18. An Investigation into Stellar Photography by Professor Pickering; see also *Astron. Nachrichten*, 1105; also *Astronomical Register*, vol. i., p. 65, which says the moon photos. were 3in. in diameter.
19. British Association Report, 1859, pp. 130, 139, 140.
20. Royal Astronomical Society Monthly Notices, vol. xix., p. 354.
21. Royal Astronomical Society Monthly Notices, vol. xix., p. 356.
22. British Association Report, 1859, pp. 139, 140; also *Astron. Nachrichten*, 1105, 1129, and 1158; also Monthly Notices, vol. xix., pp. 138 and 139.
23. Proceedings of Royal Society, 1886, No. 247, p. 207.
24. British Association Report, 1859, p. 149.
25. British Association Report, 1861, p. 96; also Royal Astronomical Society Monthly Notices, p. 278, with plate.
26. *Astronomical Register*, vol. i., p. 118, 119.
27. British Association Report, 1861, p. 95; also Royal Astronomical Society Monthly Notices, vol. xix., p. 138.
28. Royal Astronomical Society Monthly Notices, vol. xix., p. 138.
29. *Astronomical Register*, vol. i., pp. 67 and 118.
30. British Association Report, 1859, p. 137.
31. *Phil. Trans.*, 1862, p. 333.
32. *Astronomical Register*, vol. i., p. 119.
33. *Phil. Trans.*, 1862, p. 405.
34. *Phil. Trans.*, 1864, p. 428.
35. An Investigation into Stellar Photography, by E. C. Pickering, p. 181; also *Astronomical Register*, vol. ii., p. 109. A list of Rutherford's photographs is given in the Smithsonian Miscellaneous Collections, No. 311, p. 89.
36. *Quarterly Journal of Science*, 1865, pp. 651 and 652.
37. *Comptes Rendus*, 1869; also British Association Report, 1869, p. 25.
38. *Nature*, vol. xxi., p. 23; also *Astronomy and Astro-Physics*, June, 1893.
39. *Nature*, vol. iii., p. 111.
40. *Nature*, vol. xvi., p. 364.
41. *Nature*, vol. xviii., p. 643.
42. *Nature*, vol. xviii., p. 43.
43. *Nature*, vol. xxi., pp. 269 and 270.
44. *Nature*, vol. xxxi., p. 84.
45. *Nature*, vol. xxi., p. 410.
46. *Nature*, vol. xxiv., p. 308; also An Investigation into Stellar Parallax, by E. C. Pickering, p. 181.
47. British Association Report, 1881, p. 520, with plate; also *Nature* vol., xxiv., p. 464.
48. *Nature*, vol. xxiv., pp. 236 and 308.
49. *Nature*, vol. xxv., p. 132.
50. *Nature*, vol. xxv., p. 489.
51. *Nature*, vol. xxvi., p. 33.
52. *Nature*, vol. xxvi., p. 179.
53. *Nature*, vol. xxvii., p. 199.
54. *Nature*, vol. xxvii., p. 199.
55. Royal Astronomical Society Monthly Notices, xxviii., p. 88, and xxix., p. 4.
56. Royal Astronomical Society Monthly Notices, vol. xxviii., p. 88.
57. *Nature*, vol. xxviii., p. 606.
58. *Nature*, vol. xxviii., p. 255.
59. *Astronomical Register*, vol. xxiv., pp. 246-7; also *Nature*, vol. xxxiv., p. 35.
60. *Nature*, vol. xxxv., p. 37; also Royal Astronomical Society Notices, vol., xlv., p. 107.
61. *Nature*, vol. xxxi., p. 480.
62. *Nature*, vol. xxxii., p. 70.
63. *Nature*, vol. xxxv., p. 37.
64. *Nature*, vol. xxxv., p. 16.
65. In his Researches into Stellar Parallax.
66. *Nature*, vol. xxxvii., p. 616; also *Astronomy and Astro-Physics*, Feb., 1893, p. 150.
67. *Astronomy and Astro-Physics*, March, 1893, p. 271.
68. *Observatory*, vol. xii., p. 165.
69. *Nature*, vol. xl., p. 17.
70. *Nature*, vol. xl., p. 417 and 418.
71. Royal Astronomical Society Monthly Notices, March, 1890, p. 296.
72. *Nature*, vol. xli., p. 164.
73. *Nature*, vol. xliii., p. 452.
74. *Nature*, vol. xliv., p. 438.
75. *Nature*, vol. xlvii., p. 304.
76. *Astronomy and Astro-Physics*, May, 1892, p. 408.
77. *Astronomy and Astro-Physics*, May, 1892, p. 408; also Aug., 603, with two plates, actual photographs. *Nature*, vol. xlvii., p. 498.
78. *Astronomy and Astro-Physics*, October, 1892, p. 741.
79. *Astronomy and Astro-Physics*, March, 1893, pp. 255 and 260; also May, 1893, p. 463.
80. Researches in Stellar Parallax, by Professor Pritchard.
81. *Astronomy and Astro-Physics*, June, 1893, p. 351.

Section B.

CHEMISTRY.

ADDRESS BY THE PRESIDENT.

C. N. HAKE, F.C.S., F.I.C.,

Chief Inspector of Explosives, Victoria.

RECENT DEVELOPMENTS IN MODERN EXPLOSIVES.

In compliance with your request to read an address before you Association at this meeting, I have chosen a subject—I am afraid rather a dry one—but it is one I am most conversant with; and, in dealing with it, I do not consider it advisable to repeat the so often mentioned generalities about the manufacture and composition of explosives, but will only touch lightly on representative types, and on improvements which have gradually led up to the reliable propellants of the present time.

Within the memory of many here present gunpowder was practically the only explosive available, both for industrial and military purposes, but the discovery of guncotton and nitro-glycerine has gradually encroached upon its old domains and is displacing it from its former unique position. It is, however, still the most important and most commonly used explosive, both in the industries and for warfare. Within recent times gunpowder was made in a haphazard sort of way, and one kind was used for all Service purposes. It was known as a violent explosive; but no one troubled about its characteristics, or about the pressures exerted in the gun, or the muzzle velocity of the projectile. With the old smooth-bore gun, with plenty of windage, no one could predict whether the projectile would deflect to the right or to the left. But in spite of all this the obsolete gunpowder, fine grained and quick burning, was well suited to the ordnance, and very effective at close quarters. The composition of Service gunpowder has undergone very little change in recent times; but, although still a mechanical mixture of saltpetre, sulphur, and charcoal, the care bestowed on its manufacture makes it possible to obtain with certainty uniformity of results under similar conditions, as if it were a chemical combination. These results, however, have only been obtained after long study, patient research, and under difficulties which few unacquainted with the subject will appreciate. The principle

upon which improvements in modern gunpowder are based lies in the slowing down of the powder, and this alteration became necessary by the introduction of rifled ordnance. It is now required that when the charge is fired in the breach of the gun the combustion shall commence comparatively slowly, so as to overcome the *vis inertiae* of the projectile, and that as the projectile passes up the bore of the gun the combustion shall increase in rapidity, so as to supply a progressively increasing quantity of gas to accelerate the momentum of the shot, which should leave the muzzle of the gun with the maximum velocity. The Service powder known as R.L.G. represents the first attempt in this direction, and this improvement was accomplished by increasing the size and shape of the grains. A further improvement was made by increasing the density of the powder, as in P2 powder, and it was found on experiment that a charge of P2 powder equal to that of R.L.G. gave considerably reduced pressure in the gun, accompanied by an increased muzzle velocity of the projectile; but, as even these powders exerted too great a strain upon the gun, it became necessary to slow down still more, and many suggestions were made with this object in view. General Rodman, of the American Service, first overcame this difficulty with some success by building up a charge of solid slabs perforated with holes, the object being to expose a minimum surface of powder at the commencement of combustion, and an increasing surface as the projectile moved up the bore of the gun.

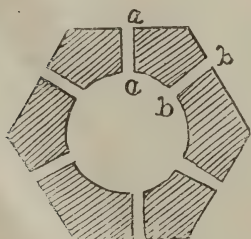


FIG. 1.

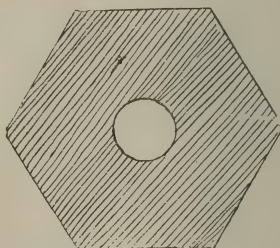


FIG. 2.

It was in accordance with this idea that the Black Prism powder was first made, and it needs no explanation to demonstrate that a charge of powder moulded to a regular shape, and of uniform size, must give more uniform results (*ceteris paribus*) than can be obtained by an equal weight of irregular grains or lumps. This modern-shaped powder, however, possesses other advantages of considerable import over the irregular P2 powder, which burns from surface to centre, and thus has a continually decreasing surface of combustion as the shot travels up the bore of the gun. The

perforated prisms, on the other hand, develop an increasing surface as it burns away, thereby keeping up a constant supply of speed-producing gas, and accelerating the speed of the projectile. In the P2 powder, therefore, we have actually a decreasing evolution of gas, whereas in the prism powder the order of things is reversed, as shown by the diagram.*

In burning it is probable that the prisms break up across the lines of least resistance, as shown in Fig. 1., *aa*, *bb*, and so on, thereby producing many new surfaces for combustion and fully developing the progressive character of the powder.

The prism form has been adhered to, but the Black Prismatic powder has been superseded by a still slower burning powder, which differs somewhat in composition from it in so far as it contains only 3 per cent. of sulphur and as much as 3 per cent. of moisture. It is known as S.B.C., or slow burning "Cocoa Powder."

This new form of prismatic powder brought about a complete revolution in gunnery. With a slower burning powder the lengthening of the gun followed as a matter of course, the chambering was increased, and the muzzle loader was converted for obvious reasons into a breechloader. "Cocoa powder" may be looked upon as the connecting link between the obsolete black powder and the modern smokeless powders. Although it cannot be looked upon as a smokeless powder, in the latest sense of the term, yet the smoke produced by its combustion is white, and disperses very quickly. It is probable that the evidence of this, brought forward in experiments with heavy ordnance and quick-firing guns, served, in the first instance, to attract attention to the necessity of reducing the production of smoke to the least possible point, and finally led to the conviction among naval and military experts that the substitution of smokeless powder for black powder in artillery and small arms was a matter of the first importance. In accordance with this view, the energies of scientists, both at home and abroad, have, during the last few years, been devoted to the task of bringing this undertaking to a successful issue.

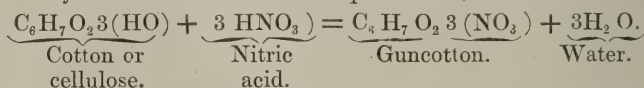
SMOKELESS POWDERS.

Guncotton in every form, *Picric acid*, and *Nitro-cellulose*, have, during the last twenty years, been subjected to experiment with the object of forming smokeless powders, but the problem, simple as it appears, presented almost insurmountable difficulties, and baffled the energies and knowledge of the most scientific chemists, so that it is only within the last few years that any approach to success has been made; and this success has been due to recent discoveries in chemistry.

* Taken from "A Lecture delivered before the R.A. Institution on January 23rd, 1893," by Lieut.-Col. F. W. J. Barker, R.A.

The following table gives the formula of—(1) Guncotton; (2) Nitro-glycerine; and (3) Picric acid. For all practical purposes these may be considered the bases of all smokeless powders.

- (1) Guncotton.—Trinitro-cellulose, $C_6H_7O_23(NO_3)$, obtained by the action of nitric acid upon cotton, thus:—



- (2) Nitro-glycerine.— $C_3H_53(NO_3)$, obtained by the action of nitric acid on glycerine.
- (3) Picric acid.—Trinitro-phenole, $C_6H_33(NO_2)O$, formed by boiling carbolic acid or phenole and fuming nitric acid.

As most of you are acquainted with the processes of the manufacture of guncotton and nitro-glycerine, it will be unnecessary to describe them, but a few details referring to their properties may be of interest.

Guncotton possesses totally different properties from gunpowder. Its temperature of ignition is from 250° - 300° C. lower than that of gunpowder, but at this comparatively low temperature it burns away so rapidly that an experiment can be made on the palm of the hand without any fear of scorching it. For the same reason a piece of guncotton can be fired on a pile of gunpowder without the powder being ignited. It is easily detonated by means of a falling weight, but the explosion is confined to the portion struck. The pressure exerted by guncotton under the most favorable conditions has been estimated by Berthelot to be 160 tons to the square inch. The fact that all the products of the explosion of guncotton are gaseous renders it smokeless. Only 50 per cent. of the products of the ignition of gunpowder are gaseous. When wet it is absolutely unflammable, but even when containing from 15 per cent. to 20 per cent. of water it can be detonated by the detonation of a dry primer of the same material. It presents many special advantages for its application in naval and military operations; but as a smokeless powder it possesses one serious drawback, viz., it does not produce a satisfactory proportion of permanent gases during combustion, and, under certain circumstances, the violent local action of the explosive makes it, *per se*, unsuitable and highly dangerous as a propellant.

Nitro-glycerine enters into the composition of a very important class of explosives possessing the generic title of "dynamite." When pure it is a colorless mobile liquid, of sp. gr. 1.6 at 15.5° C. When ignited in small quantities it burns slowly away, but when heated to the temperature of 188° C. it explodes with great violence. When spread in a thin layer it is extremely sensitive to slight concussion or blow. At a temperature of 4° C. it takes the crystalline form, and in this condition is far less sensitive to concussion or

blow than when in the liquid condition. Some idea of the "power" of this explosive can be gathered from the fact that, under the most favorable conditions, 1 cub. foot of nitro-glycerine on explosion would expand to 10,000 cub. feet of gas in the short space of $\frac{1}{24,000}$ second.

Picric acid, which is largely used as a dye, was first investigated by Sprengel, in 1873, with regard to its properties as an explosive. Exhaustive experiments were carried out by Colonel Majendie, R.A., and Dr. Dupré, F.R.S., which went to show that picric acid could be readily detonated by so small a quantity as five grains of fulminate of mercury, and that such detonation would extend to picric acid containing over 14 per cent. of water. In fact, when detonated, this acid behaves very much in the same way as compressed guncotton, as regards sensibility and the power of transmitting the initial detonation of the dry material to the same substance wetted. The products of the explosion of picric acid are gaseous, and consist of aqueous vapour and actively poisonous carbonic oxide. It is used in the manufacture of the French smokeless powder known as "Melinite."

The important discovery made a few years back by Mr. Alfred Nobel, that a certain kind of collodion cotton was soluble in nitro-glycerine, may be looked upon as the first step towards a new era in smokeless explosives. This new explosive, known as "Blasting Gelatine," consisting of 90 per cent. of nitro-glycerine and 10 per cent. of collodion cotton, formed a very powerful compound, which, while suitable in an eminent degree for industrial purposes, was found to be too violent for Service purposes. The problem had yet to be solved, viz., how to tame this explosive, *i.e.*, to impart to it a sufficient energy for use in modern arms, combined with certainty and regularity of propulsion. To the unscientific mind this problem seemed easy of solution. The properties of guncotton were well understood; all that was required was a diluent or retarding agent, to slow down the violence of explosiveness; but the first approach to success was again due to the untiring perseverance of Mr. Alfred Nobel, who found that guncotton could be incorporated with nitro-glycerine in equal proportions, and that when combined in such proportions an explosive was formed, even without the addition of any retarding agent, which was thoroughly reliable for Service purposes. It is a curious fact that two of the most violent explosives known, when combined, form a moderate explosive completely under control. The working out of this observation has led to the production of one of the most valuable of smokeless powders. This powder, known as "Ballistite" or "C/89," consists of nitro-glycerine and guncotton, and is prepared in the following manner:—

The nitro-glycerine and guncotton are placed in a vessel and the temperature raised by means of hot water, the contents being agitated until the whole mass has gelatinised. It is then placed

between rollers and rolled out into thin plates. These plates are cut into strips, and then into cubes, the thickness of the plates being regulated according to the purpose for which the powder is intended to be used. This powder has a horny, brownish-yellow appearance, and is so soft that it can be cut with a knife.

The composition of "Cordite," the new English smokeless powder, though similar to is not identical with that of Ballistite. A committee of distinguished chemists in England, appointed by Government, determined after long investigations that the ingredients of Cordite should be as follows:—

Guncotton	37 per cent.
Nitro-glycerine	58 per cent.
Mineral jelly or vaseline	5 per cent.

100

The method of manufacture differs somewhat from that of Ballistite, in so far as the properties of acetone in dissolving guncotton are applied. About 20 per cent. of acetone is poured over the ingredients in the incorporating machine, and the charge is worked up for several hours until it has the consistency of dough. When completed it is taken to the press house, where it is placed in a machine of similar construction to a pump, the cylinder of which contains a small perforated hole at its base; the pressure of the cylinder on the soft material forces it through the hole at the base of the cylinder, through which it is squirted in the form of a cord of any required thickness. The sizes vary from .0375in., used in small arms, up to 0.5in., for heavy ordnance. The cord is wound on reels for the small arm powder, and cut into lengths for the purposes of heavy ordnance. Experiments on a large scale have given most satisfactory results, both as regards its ballistic properties and its safety in manufacture, storage, and handling. Consignments of this explosive have been subjected alternately to the cold winter of Canada and the tropical heat of India, and it has been found on examination to be quite unchanged.

Invention in smokeless powders is in its infancy, and it is impossible to say what the near future may bring forth.

The question which has often been asked, as to whether there is any urgent need for smokeless powders, has not yet been fully answered.

The direct advantages claimed in the case of cordite are—

- 1st. Increase of rapidity in firing, combined with greater accuracy of aim.
- 2nd. Higher velocity and flatter trajectory.
- 3rd. A diminution of the weight, thus allowing a larger number of rounds to be carried.
- 4th. Absence of fouling.

For quick-firing guns and masked batteries the advantage is obvious, and it is not too much to say that their full effect is undeveloped without it; but for the ordinary rifle in the hands of a soldier the advantage is not so clearly apparent. The firing of blank cartridges at a review can hardly be considered a satisfactory test, nor does it afford sufficient experience to enable a complete answer to be given to this question. It is, however, certain that the general adoption of smokeless powder will change both the strategy and tactics of war.

Section C.

GEOLOGY AND MINERALOGY.

Address by the President, Sir James Hector, K.C.M.G., M.D., F.R.S., on "The Progress of Geology in the Southern Hemisphere during the past Year."*

* The manuscript of this address was not forwarded in time to be inserted here. If received before the volume is completed, it will be found in an appendix.

Section D.

BIOLOGY.

ADDRESS BY THE PRESIDENT

C. W. DE VIS, M.A.,

Brisbane.

LIFE.

By a custom which has risen almost to the dignity of a law, the President of a section is not at liberty to invite his colleagues to proceed to business until he has discharged a preliminary duty; and how to perform that duty in the most useful manner has doubtless been in all cases a matter of serious thought with those to whom it has been entrusted. If we share the opinion of many who think that the tendency of all official duties appointed to be done on behalf of this and kindred associations is necessarily determined by that peculiar mode of advancing Science which is prescribed by their constitution, we shall conclude that loyalty enjoins us to keep steadily in view the main reason which induced the founders of associations of the kind to adopt a mode of procedure so entirely foreign to the habits of all other bodies having the same excuse for existence. Sedentary science became locomotive, not chiefly to enable its agents and friends to assemble together periodically in response to distant invitation, though the personal and corporate benefits arising from mutual intercourse and extended experience are obvious and manifold, but to heighten the scientific level of general intelligence in whichever of its chief centres they might happen to meet. The expediency of bringing the outside world of thought into more intimate relation with Science dictates our peripatetic policy, as clearly as the need of instructing the farmer in his art defines that of similar associations for the advancement of agriculture. It is by raising the spirit of emulation that each travelling body seeks to compass its purpose, but in our case there is a previous requirement which does not exist in the other. A profound sense of the value of soil culture is almost instinctively confessed by the rudest farm laborer; our estimate of the worth of Science culture is more exposed to cavil

Though soundly based on experience of its results and strongly supported by the general predilection for prying into nature shown by civilised man, it is yet liable to be questioned by prejudice or negatived by that more contemptuous opponent which in its monopolising ignorance arrogates to itself the style of practical common sense. A friendly feeling towards Science, rising into a genuine delight in its intellectual charm, must antedate the emulation which will, we may hope, direct an irrigating stream of new laborers into our fields; a vivid expectation of its material rewards must precede the emulation which will suffer no one of our communities to be long distanced by the rest in their endeavor after that which is even now seen to be the foundation of national leadership—pre-eminence in the dominion of mind over matter. To foster this feeling and this expectation is undeniably the fundamental purpose of the body of which we are members. To this end our sections invite their hosts to accompany them in their researches, to participate in the discussions which at once enliven and enlighten their proceedings, to criticise proposed applications of theory to practice, to bring forward new discoveries or speculations of their own; for all this they know to be the most efficient means of eliciting curiosity, arousing interest, and demonstrating that Science claims no more at their hands than she deserves. But it is also a means which may safely be left to those whose function it is to supply our sections with the fruits of study. Whether he who is required by his office to open the business of a section with an introductory discourse should, like his colleagues, address himself on that occasion to a subject of detail and therefore of limited interest and not rather use the opportunity of aiding the cause in less abstruse fashion by inviting the friends of the section to meditate on themes of more general moment is, of course, a matter of opinion. In adopting the latter course I may perhaps be laying myself open to the charge of taking a too partial view of the intent of the Association; still I am apt to think that by so doing I shall best consult the interests we all have at heart. But, purposing to speak for the moment on some biological generalities alone, I find myself under the necessity of soliciting the forbearance of those among my hearers who will necessarily find what I have to say trite and jejune. Perhaps their forbearance will be extended to me the more contentedly if it should appear to them that in this, as in other instances, it may be useful to have the memory refreshed concerning matters with which we are perfectly familiar but not always in mental contact.

The unity, the continuity, and the nature of that which is the one mine for biological exploitation—life—are among the many questions which, on presentment, would be likely to generate a desire to know how or to what extent they have been solved by systematic inquiry. These may be chosen for consideration, though it be with undue brevity.

The young student in biology would think it almost incredible that one who has not lived through two generations should be able to recall from among the thoughts of adolescence the crude conception of plant life which then lodged in his mind, undigested by the pepsine of scholarly instruction as at that time imparted. That plants had life of a kind appeared evident; they grew, multiplied, died, and decayed; they even showed signs of irritability. Yet it seemed little more than a metaphor, a concession to the poverty of language, to speak of vegetables being endowed with life such as other organisms possess. In this, as in most respects, plants appeared to be as foreign in nature to animals as animals obviously were to man. The times change and we change with them, but the margin of a pool long remains unruffled by the waves that creep from its disturbed centre. At the present day the same traditional opinion in favor of the fundamental diversity of life in the animal and vegetable realms would be professed by numbers of reflective persons whose intellectual exercise has not carried them within the pale of biology. It may then be asked of us, Have you by searching found out anything to the point? We can answer in the affirmative; it has long been established beyond doubt that life in the plant and life in the animal, phenomenally so discordant, are substantially one and the same. The steps by which biology has mounted to this eminent conclusion—eminent because from its height we can take a bird's eye view of life in all directions—are worth recounting. Their story will one day form an interesting page in a history of knowledge.

For nearly 150 years there has been known a substance scattered in minute masses through water, where each particle discharges on its own behalf every essential function of animal life—motion through space, extension and retraction of parts, quest, selection, ingestion and assimilation of food, circulation of fluids, secretion and excretion, respiration, and reproduction—in all these modes of activity automatic, yet without definite organs or members, without so much as a containing investment. To us the creature is partially intelligible; but in 1755, the year of its discovery, *amœba* was a passage in the volume of life utterly undecipherable, and, as a cryptogram teaching nothing, it was suffered to lie for eighty years almost forgotten. Meanwhile the intimate structure of plants was being scrutinised by anatomical botanists, some of whom found that the cells, which appeared to be the structural elements into which all plant tissues could be resolved, were in certain cases and circumstances capable of exhibiting automatic movements. These observations also were impotent of results, but lay as isolated facts, unincubated till others were placed around them, and all stimulated to find their way to light together. Zoologists on their side had been pursuing a parallel path, and had learned that animal tissue was structurally nothing more than a system of cells. They now pushed the inquiry further, putting

questions to the cells themselves; and in 1835 one of them, in his study of the foraminifera, made an epochal discovery—he ascertained that the vital properties of the cell are peculiar to a portion of its contents, a transparent slime insoluble in water, and, though irritable, apparently structureless, and to this he gave the name of “sarcodæ.” Eleven years later botany brought up its arrears of progress by demonstrating that a like substance was the seat of energy in the vegetable cell, but, unconscious that it could be other than newly discovered, called it by another name, “protoplasm.” Of course it was not long before the two substances were rigorously compared one with another in all their known phases and conditions of existence. The result may be anticipated—sarcodæ and protoplasm were found to be identical. By a further deduction the presence or absence of a limiting envelope was rendered a condition to which the physiological completeness of the cell was perfectly indifferent. As an abstract conception the cell became the prisoner, and that though the prisoner were unconfined. Then, by the way, it came about that *amœba*, so long overlooked, was remembered, and found full of interest as the first-discovered realisation of the ideal of a living cell, a cell, moreover, with independent life. Protoplasm now became, in ordinary but expressive terms, “the physical basis of life” common to the two great kingdoms of organisation. But the whole life of an organism being but the sum of the life of its constituent cells, it follows that the life of the one-celled plant that tinges the arctic snow and that of the many-celled animal that tames to his will the restless energies of nature differ only by the phenomena resulting from modifications of their common protoplasm. The conclusion is not affected by the event that protoplasm has been proved to be by no means the structureless substance it was long accounted to be, and therefore not that immediately convenient source of structure that the real physical basis of life must be. The properties of a precursor of protoplasm are but the more remote properties of the substance from which plant and animal were to arise through the intermediacy of protoplasm.

It has been a happy consequence of the establishment of the doctrine that life is identical wherever it exists, that the partition which during all time stood between two companies studying almost within mutual touch was thrown down. The schools of botany and zoology recognised that the book before them was the same, however differently its volumes had been edited, and thenceforth united in the endeavor to find its full and true interpretation. A higher category inclusive of both their sciences had arisen, and for its common denomination they had no choice but to adopt that of the science of life—biology. A great step had been taken; but if this category prove, as it will assuredly, to be but a constituent of a still higher one, whose terms will bind together the organised and the unorganised, a still greater advance will be made towards

solving the great problem of all Science—find the prime motor of secondary causes. Meanwhile it is a fact fraught with significance to a thoughtful man that all living things are of the same vital substance with himself.

Reflection on the oneness of life, fruitful of good to the moraliser as to the knowledge-seeker, becomes far more edifying to both when life appears to the mind steadfast in continuity.

In the early days of biology its ablest expounders rarely or never doubted that, under favorable circumstances, life could spring up where no life was before. The fact that it commonly entered its arena by process of descent did not compel them to question the truth of the general opinion of the age that living things frequently issued fatherless from the womb of unknown conditions. They had not, indeed, a broad unswerving base of experience on which to found a generalisation which should exclude that assumption; nor was the tenet held fast by all around them that life, as ordinarily acquired, is a special gift to the unborn, a guide to the path of heterodoxy. It was by slow degrees that observation gave form to suspicion, and, pouring down a fuller volume of rays, ripened it into certainty that in the ordinary course of nature abnormal generation was not in the least likely to occur under any contingency. In our own day attempts to prove by exact experiment that the well-tried maxim of biology, "Life from the living only," may not be unexceptionally true, shows that the inheritors of the discredited hypothesis still number among them men of scientific training; but these are certainly not the revivers of an obsolete doctrine. That absence of biological knowledge which permitted a past generation to believe that geese of certain kind were the fruit of a tree, and which among our Australian selves—even amongst our educated selves—sees no difficulty in maintaining that the young kangaroo is born on the nipple of its mother, will long bar the mind against the conviction that external circumstances alone are powerless to produce life, will long throw the imagination open to entertain a fallacy which may indeed be less grotesque but is not less inconsequent than these. Biology does not, of course, assert dogmatically that the reintegration of life, which is really meant by the term "spontaneous generation," is theoretically impossible; it seems to her only less conceivable than that primæval integration of life, which, if terrestrial, was in a sense spontaneous generation, but she does say that, after decades of toilsome research into the obscurest recesses of nature by her acutest experts, she has never met with an instance in which life came into existence by its own will—an obvious absurdity—or by abnormal means. In defiance of the advocates of spontaneous generation she declares that every plant or animal is, in its inception, necessarily a part of a similar body pre-existing. In opposition to mistaken conceptions of generative methods founded on inconclusive observation she teaches that these are not subject to violent revolutionary changes

in particular instances—that, for example, all geese are, like other birds, hatched from eggs; all marsupials, like other mammals, born from the womb.

But constancy of parentage is not to all minds a sufficient explanation of the origin of life in the individual. It is possible for a living body to derive its substance from its progenitors, its life from some extraneous source. If this were more than a gratuitous hypothesis, if it were supported by any evidence whatever, one of the further questions which biology has yet to solve would tend towards solution. Not only should we then have some reason to think that life is not simply the quality of living matter, but an entity capable of existing apart from it—a view which has been gradually shut out by every increment of knowledge; but we should be inclined, in proportion to the proof offered, to believe that even under present terrestrial conditions a substance capable of life can exist apart from that which alone proves its capacity for life—a rather profound problem, and one not to be solved by offhand inconsiderateness. But the evidence is wanting and the assumption is improbable in itself. There are three possible modes by which the incipient organism may receive life, and of these we, as reasoning men, must choose the most reasonable, remembering the while that it is life simply, the common attribute of plant and animal, that has to be considered, and disallowing all exclusive thought of ourselves and our human gifts. Either the offgoing part of the parent is dead, an effete excretion, and life is introduced to it from without, or it is a living part from which in the process of separation inherent life is expelled in order to be replaced by life from without, or the life of the offspring as a separate body is in uninterrupted continuity with that of its parent substance. Remembering again that nature works in the ways that are most direct, and that she secures economy of labor by never doing anything, on the large scale at least, unnecessarily, we shall have no difficulty in fixing the respective values of these alternatives and assigning the highest to that which affirms continuity between the two terms of life, the old and the new. But biology does not leave us to judge by mere likelihood. She declares that her peculiar instrument, the microscope, has revealed to her as a fact that the initial point of life is not only of itself a living being while still an intrinsic part of the parent body, but that after separation it necessarily carries forward the parental life. She is shown a living body gradually constricted in the middle till it parts asunder, and each half goes its living way, a part of the body wall bulging outwards, and assuming more and more the form of a body similar to that from which it sprung till it either drops off more or less fully accounted for independence or grows up to maturity without losing its connection with the parent mass. In these cases continuity of life, if not in the latter case continuity of the entire substance, is beyond question. Between these instances of life—at once extended

by means which limit its range in time and space and the dispersive mode of reproduction which as a rule provides for the extension of the organism both in time and space, by storing up in a more or less enduring form, as spores, seeds, or eggs. the capacity for future development without necessary dependence on the integrity of the parental life—there are several gradations of method, but at no point do we find the thread of life—continuity between parent and embryo—snapped apart. Whether scattered through the body or located in a special organ, the cell of protoplasm prepared for the reproduction of the whole series of vital phenomena manifested by the congeries of cells around it has at least as great a share in the process of preparation, and therefore as great a share in the common life, as each one of them, and that life, unless prematurely destroyed, never ceases till it has accomplished its cycle of development, for organised as protoplasm is now known to be its further organisation proceeds without a break to maturity. As far then as parent and offspring are concerned, it may be held indubitable that they have the selfsame life consecutively embodied.

Here I am tempted to pause and ask my fellow biologists and myself whether this truth, to them so unnecessarily spoken, does not impose a duty upon us as citizens of our respective States, as sharers in that commonwealth of humanity in which, however absorbing our special pursuits, we must feel a personal interest. Life as we know it, not only in its ordinary functions, but in its idiosyncracies, and in their necessary influence on things external, is transmitted unbroken from parent to child. Intellect or idiocy, physical vigor or decrepitude, virtue or vice, are conferred or inflicted on the issue of the body. It is a very solemn thought. Truly it is a matter for anxious inquisition and resolute action on the part of those whom we appoint conservators of our health, our morals, our education, and our property. Remedies for inherited evils are as plentiful as they are ineffectual; every man has his specific—for the encouragement of the good that is born with us we have our schoolmasters and our divines—but, whether to implant or displant, we want to grip the tap-root of the matter. The savage, well aware that the existence of his tribe depends on its freedom from useless and noxious members, its vigor on the renunciation of close marriage and the restriction of marriage to the fully matured, and among them to the stoutest, bravest, and wisest, and conscious that for his own welfare he should prefer the life of the tribe to that of any injurious particle of it, obeys without compunction the death-dealing decisions of tribal policy. The storage of foods or its equivalents, the mainspring of civilisation, relieves us from the necessity of ridding ourselves of the unproductive units of society; so far we are privileged to indulge the so-called humanitarian sentiment with safety—we may even go further and tolerate the presence amongst us of the less hurtful of

our mischief workers. But it follows that we have the greater necessity for compensatory measures tending to restrain the procreation of any predisposition to disease and vice, and to encourage, on the other hand, the production of a superior manhood. Some measures of restraint at least, some measures of stimulation perhaps, are within the range of practical statesmanship, and the statesman who with a far-seeing eye to his country's good will give them shape will earn its gratitude and that of the civilised world. At present it is curious to witness the stockbreeder's watchful pains to avert from his stud the slightest taint of inferior blood, and the politician's utter indifference to all precaution of the kind, or it may be his dread of the obloquy which would be his were he to meddle with this one of the greatest of all causes of criminality and folly in the body politic. But the public opinion he fears will one day say in chorus that it is a crime to perpetuate anything obnoxious to the public weal. It will have realised to itself the mighty though noiseless battle that is raging in every community between its strong desire to rise in the scale of man's development and its equally strong inclination to yield to agencies of debasement. It is the struggle of the diver in the embrace of the cuttlefish whose arms are beset with the suckers of moral and physical degeneracy. Biologists are neither statesmen nor social reformers by profession, but in all that pertains to heredity they stand in the position of trained advisers to the public and its leaders; and in a matter of such grave import they should not hesitate to declare that ordinary experience of the influence of heredity on domesticated subjects is but an experience of a natural law which controls for good or evil man, equally with all other organisms, and to remonstrate against allowing the human subject to continue exposed to its influences so far as they are malignant. Their remonstrance will probably long fall on inattentive ears. Men and women are inert to think an application of the principles of successful breeding requisite in their own case; and will remain so, resentful of any interference with their liberty of choice, until trained to subordinate self-indulgence to the common good. In time, however, we may hope to make some impression on the public mind, if it be only the natural effect of our insistence on that absolute continuity in the life of parent and child which has led to this digression.

To predicate continuity of life between parent and offspring in the present is to affirm the same of all such relations as far back as human experience reaches. But present life is at one step backward in geologic time found associated with, at the next seen emerging by insensible gradations from, past life—no chasm of death exists between them. All known life then comes under the same predicament, and we are inevitably led back to its first appearance on the earth. Assuming the truth of the conception of cosmical evolution known as the "nebular hypothesis," the one attempt at cosmogony so far successful as to be able to harmonise

known facts and withstand rational criticism, there must have been a period in the history of our earth when the existence—or at least the permanence—of life upon it first became possible. Previous to this the elements entering into the complex composition of that which we at present recognise as the sole manifestor of life—protoplasm, or more probably of some much simpler forerunner of protoplasm—were not permitted by physical conditions to combine in suitable proportions, or at least to remain in combination—the earth's temperature, for example, continuing higher than that which now forms the limit of life endurance. Whenever by secular change such inhibitory conditions became gradually relaxed, it is conceivable that a critical point would at length be reached at which a form of energy, till then excluded from this mundane sphere of action, could begin to operate upon the material placed in readiness by some one of the combinations effected by the chemical experiments of that energetic period, and life would commence. It is usual to stigmatise this hypothesis of the origin of terrestrial life as a materialistic extravagance based on a "fortuitous concurrence of atoms." The epigram is good logic to those who believe in—or, at the most, have an unintelligent disbelief in—the supposed fact that the result of a toss of a penny or a throw of the dice is purely a matter of chance, unconscious that it is as much a prescript of law, the outcome of an antecedent combination of conditioned forces, as all things else in nature. The muscular play in the hand that throws, the form in all its parts of the cavity whence the dice are thrown, the shapes, sizes, and specific gravities of the dice themselves, the properties of the resisting bodies on which they fall, the density of the medium through which they are projected—were all these beforehand calculated, and in the act controlled, the expert could throw just what number he pleased. To speak of the effect of a sequence of causes rationally believed to exist, though imperfectly or not at all known, as gratuitous, merely exemplifies the propensity to throw from under the veil of wit dust into eyes which might perchance see more clearly than we wish.

It is reasonable to suppose that the beginning of life on the earth could occur but once, since secular change, ceaseless ever after as before initiation, would eventually leave in the rear that state of things which had proved favorable to its occurrence. We have no right to assume that its terrestrial origin was equally possible under two different sets of conditions. It is certain that there is an opportune period for the appearance and career of each living thing, and that this period once passed never returns. No fact in palæontology is better established than the inability of an extinct organism to re-enter the stage of life; and as life must have been introduced in some plastic form which is not known to exist now, we may fairly infer that this form never did and never can exist twice. It is therefore allowable to repeat that the reintegration of mundane life, the possibility of which under present conditions is

presupposed by believers in spontaneous generation, is less conceivable than its primary integration. In the words of the author of "The Correlation of Physical Forces"—"Nothing repeats itself, because nothing can be placed again in the same condition. The past is irrevocable."

But it is obvious that the argument as to time does not apply to space conditions. It is not only unnecessary to suppose that life began in a single speck of plasmogen, and thus incur the necessity of tabulating a common pedigree for all organisms, but it is needful to admit that probability points in the opposite direction. If life activity became set up as a consequence of a secular change the opportunity for its being set up was probably cosmopolitan, and the probability of its failing to be set up in more places than one very little. It is therefore admissible at least to regard it as commencing at several points in the earth's surface simultaneously, that is, within the limits (possibly of enormous duration) of the one period of change which allowed its introduction.

It has been suggested that the origin of terrestrial life may have been due to a biogenetic agency previously excluded from operation on the earth. On the subject of extra-mundane life speculation has long been active, and, as the wont of speculation is, useful as a stimulus to continued inquiry. It may be well to note, by the way, how the question stands at present. Are we compelled to believe that this earth, a mote in the universe, is the sole receptacle of life? Clearly not, since that belief could only be founded on the knowledge that life is impossible elsewhere. Are we then, on the other hand, justified in concluding that life is not restricted to our globe? Clearly not, since all the reasons advanced in favor of the opinion show nothing more than either its probability on general grounds or the absence of non-prohibitory conditions in particular cases. In combination they cannot lead to anything higher than probability, but it is a probability, be it observed, that is not countered by any weight at all in the opposite scale. It would seem on the face of it hopeless to wait for some unmistakable evidence of the actual existence of life outside our planet, yet a seemingly near approach to the evidence required has more than once been reported. For instance, on the 9th of June, 1889, there fell at Migheni, in Russia, a remarkable meteorite. On a cursory inspection, it appeared to be of a carbonaceous nature; on being handled it proved to be very friable and apt to soil the fingers. External aspect, friability, and soiling to the touch may all have been due to an unusual proportion of carbide of iron. But it is said that chemical analysis showed the substance to be of the customary meteoric composition, with the addition of nearly 5 per cent. of organic matter, and that this matter, extracted with alcohol, yielded a bright yellow resin much resembling kabaite. Moreover, we are told that a cold aqueous extract of the substance contained an organic salt and nearly 2 per cent. of mineral matter possessing

properties of a novel character, such as giving a heavy white precipitate with baric chloride which was not baric sulphate, and a peculiar precipitate with argentic chloride. The weak point in the study of this meteorite was that its so termed organic constituent was not, prior to chemical treatment, subjected to microscopical examination for the detection of structure, but the fact that it yielded a resin to alcohol points strongly towards the reality of its organic origin. This case, indeed, seems to have advanced us a step beyond the state of vague suspicion aroused by certain famous American meteorites in which the presence of diamonds is said to have been demonstrated. By a pretty general consensus of opinion diamonds are of organic origin. It has, however, lately been announced that they have appeared among the by-products of a furnace, and, if so, the antecedent difficulties of accounting for the presence of organic matter in a meteoric body and for its passage through the atmosphere undestroyed are diminished. At any rate, if, as there seems no reason to doubt, life products have been found in meteorites, it will be difficult to escape the conclusion that life is not confined to this earth. It is therefore quite possible that in the first instance it may have been transmitted to us from without; but, as frequently remarked, this, though it prove to be a fact, cannot affect any conclusion we may reach as to the mode of the origin of life. It will merely compel us to decide that life is not peculiarly an attribute of the earth, but that it had a birth-time and place in the infinities of the cosmos.

It is only natural that the mind which is apt to claim a monopoly of reasoning power should tend to speculate on the nature of that which underlies all reason, that, too, which is certainly the most energetic factor in the superficial economy of this globe, and very possibly in that of many others. A present mystery life is undoubtedly. A perpetual inscrutable mystery it is said to be with the surest confidence, and they who say so must be wise, for who can say so but he whose mind is a true measure of the utmost reach of human intellect in all time to come. Modesty, however, suggests that in the light of the revelations of the last tenth part of the Christian era it may be as presumptuous to pronounce any object of natural inquiry to be out of the range of the intellect of the future as to assert the contrary; nor does it well become those whose stimulus to labor is the hope of solving or of helping to solve the most intricate problems of nature to hug to their breasts that darling of inane contentment—inscrutable mystery. Excluding all but purely physiological views of the question—What is life? let us endeavor to formulate a conception of the meaning of the term "life" in its most comprehensive and, therefore, truest sense. For this it is necessary to clear the way by dismissing to oblivion the long dominant opinion that the life we speak of is a being capable of existing apart from body, resident

in matter for temporary purposes, and, these fulfilled, quitting it for another phase of existence. Such terms as "vital principle," "organising agent," in the sense of a presiding genius regulating bodily functions, have become almost obsolete in biological literature; the generation which from a scientific standpoint upheld the hypothesis of its existence has well nigh passed away, and left to the conservatism of popular sentiment the struggle against the logic of fact. But though it is perfectly clear to most physiologists that life is not an embodiment of anything at any time external to the body, what it actually is, is less unanimously decided upon by them. By many it is defined to be "the sum of the actions of an organised being;" others, very properly objecting that the actions of an organised being cannot of themselves constitute its life, prefer as a definition "the state of the actions peculiar to an organised being," and an improvement on this again is made by those who say it is "the condition of activity manifested by such beings." The defect in all these renderings seems to be the uncertainty attaching to the unqualified use of the terms "action" and "activity," a defect which may perhaps be remedied by defining life as "the molecular activities peculiar to organic structure." It is the consequence of the formation of a substance susceptible of organisation under the impress of that mode of intramolecular motion. Its prime phenomena are irritability—aptness for automatic motion in mass in response to stimuli, and metabolism—the faculty of converting irritants of a suitable kind into nutrients, suitability being determined by elective means akin to if not identical with chemical affinity. The molecular activity in which life consists is the ultimate fact in this direction, and must remain so until the time is ripe for resolving all modes of energy into one. So far as this peculiar activity produces peculiar effects, life must for the present be held distinct from those energies which are incapable of bringing them about. On the other hand the production of phenomena identical with those which are characteristic effects of the physical energies warns us against the assumption that life has in its nature nothing in common with them. The molecular activity—life—is apparently convertible into the other molecular activities; the work done by the contracting muscle-fibre appears partly as heat, partly as electricity, that of other tissues as light, of others as chemical synthesis or analysis. Were the question between any two of these physical forms of energy, such convertibility would be held to indicate mutual relationship, and though no one of the latter is, so far as we know, convertible into life, this is hardly sufficient ground for regarding the organising activity as essentially different from the non-organising.

Seeing that the operations of ordinary chemism within the body are directed and controlled by vitality, and are at the same time necessary to the continuance of vitality, it is conceivable that life is a concurrence of the two modes of molecular activity mutually

adjusted and equilibrated, *i.e.*, of two sets of vibrations of different velocities and different amplitudes. This is pure hypothesis, but it goes in the direction towards which the tide of opinion is strongly setting—the correlation of life energy with those which work physical results only.

As though springing from the same root stock in the mind, the twin ideas of life and death rise so constantly together that to regard the one and neglect the other would be, in the language of the chemist, to leave a bond unsatisfied; but what can even a biologist have to say of death more than that it is the universal bourne? He may, indeed, discredit the ordinary notion which by erecting metaphors into facts succeeds in evolving a positive out of a negative, and creates for itself death as a real presence. He may, at the same time, guard against hasty conclusions in cases where the occurrence of death is liable to be affirmed on insufficient grounds, by defining it as the absolute loss of the power of evincing the phenomena of cell life; but what then? Death comes to all, and there an end. All that lives dies is the verdict of universal experience. But many biologists are not so sure as once they were that death does come to all of necessity, that individual life must from its very nature and work come to a stop. Ground for asserting that some organisms are potentially immortal has been found in the leading feature of the life-history of amœba and those other monoplastids that propagate by fission of the body into equal parts. Apparently no valid argument can be adduced against the conclusion that the mature cell undergoing fission does not die. As a unit of life it disappears, but surely it is an abuse of terms to call that death which leaves nothing to show that life has ceased. But though in attaining the end of its existence the cell has acquired immortality, it does not follow from this that prior to maturity it has no inherent tendency to die. There is little doubt that in the higher organisms normal death ensues from the excess of cell waste over cell production, and that this again is the necessary result of the cells being too hardly worked. Cells, like citizens of a commonwealth, have a double duty to perform—to feed and reproduce themselves, and to discharge whatever functions are committed to them for the benefit of the community. In proportion as these latter are more distinctly specified the ability of the cells commissioned to execute them to effect growth and reproduction is diminished because a portion of the energy which should have been expended on self-maintenance is diverted from it, and the more excellent the work performed as a consequence of the division of labor the less aptness of the workers to provide for their own wants. All this is obvious enough in its application to many-celled organisms. But it is claimed that in uni-cellular organisms, whose parts are not distinguishable one from another, there is no division of labor; it is the whole of the cell which reproduces, assimilates, excretes, and so forth. I must

confess that, for my own part, I find it very difficult to conceive that every particle of the protoplasm is equally capable of performing these different functions, nor does the necessity of doing so seem so imperative now that we know that a certain degree of organisation is present in cell matter. Because we cannot as yet distinguish differential media of function in the structure of the monoplastids we are hardly at liberty to build theories on the assumption of their non-existence, and conclude that these organisms are exceptions to the otherwise general law of cyclical life. In view of the fact that all nucleated cells, and probably all non-nucleated monoplastids, conjugate and undergo a certain, however slight, change in the molecular arrangement of their protoplasm, a change followed by a period of incubation preparatory to the renewal of reproduction by fission, it seems likely that this process is in them, as in the higher organisms, necessary to the reinstatement of life in the vigor of youth, and that were this process prevented they would become incapable of fission and die. The renewal in the offspring of the energy, not exhausted, but diminished in the parent, appears to me to be at least as much the purpose of conjugation as the commixture of heredity courses and that no less in the protozoa than in the metazoa. The immortality of the former is not potential but incidental to the attainment of maturity. A defender of the theory that reproduction is established solely for the purposes of heredity might urge that the higher rate at which vital processes go on in the earlier stages of individual life is not due to a renewal of energy as a primary intention, but that this is the necessary means by which alone the product of the fusion of hereditary tendencies can be brought with speed to maturity and so enabled to escape the perils of youthful feebleness. Rapid growth is merely an adaptation brought about by natural selection. But heredity itself is as much a process of utility to the species as reinvigoration is to the individual; adaptation, common to both cases, does not affect the real significance of either. On the whole, it is perfectly true that the monoplastids are conditionally immortal, but there is not sufficient evidence to show that the condition being unattained, they are not potentially mortal.

To these few of the biological themes which have an attraction extending beyond the pale of Science it would have been a pleasure to add that great, and, so far as the public mind is concerned, still unsettled question—the origin of species. Evolution, whether by natural selection or other secondary causes, stands now in almost the same relation to biology as gravitation to astronomy. It is the master key which, in the hands of the expert, is constantly opening to the light the recesses of nature; it is repeatedly explaining the apparent contradictions and inconsistencies met with in his researches; and, above all, it is conferring upon him the power of anticipating discovery by enabling him to inform us with a very great degree of probability, followed by verification, of otherwise

unexpected facts. No wonder that such a theory should be unanimously accepted by those who can appreciate its power for good. No wonder that its beneficiaries should be desirous to see it entertained on its merits by all persons of intelligence. But I have been speaking too prodigally on other topics, and time fails.

In a gathering of the sciences it would be bad form to recommend one to special favor rather than another. I feel hardly at liberty to say even this much of biology: that from it emanates the ætiology of body and mind, and to ask on what but this depends the happiness of the individual, the maintenance of the society, the future of the race? Add to this the purely intellectual profit accruing from close study of the operations of life in the world or worlds around us, and we cannot deny that biology well deserves the utmost encouragement we can give it. That encouragement she is here to seek, and happily she can seek it here with lively gratitude for help already given. Coming from a State which has not as yet made provision for academical research in biology, I can feelingly congratulate those who have on this occasion extended a welcome to our Association, that they have had it in their power, and not neglected the opportunity they had, to secure to themselves the priceless boon of university teaching in addition to other potent means of mental culture. Though fully alive to and grateful for the splendid work which has been done and is being done by private biologists in all departments of the science, we cannot, if we would, gainsay the fact that the greatest mass of the best results is effected by those whose only occupation it is to learn that they may teach, and amongst the bodies set apart by public foresight for such purposes the universities throughout the world are conspicuous for the excellence and multiplicity of their biological labor. Were it not the merest presumption in me to thrust advice upon the intelligence of South Australia, I would, in the interest of biology and through it in the interest of the State, say to them— Cherish your university, extend its searching power, amplify its teaching power with all your might, and do not be too solicitous to see it exercising an immediate influence upon your national progress—the nimblest ox is not usually the best worker.

Section E.

GEOGRAPHY.

ADDRESS BY THE PRESIDENT,

A. C. MacDONALD, F.R.G.S.

THE SCOPE OF GEOGRAPHY, AND THE ADVANTAGES
OF GEOGRAPHICAL EDUCATION.

It is with no small amount of diffidence that I rise to address an audience such as I have the pleasure of meeting here to-day, for, as I only claim to have the same general interest in geographical research that should be taken by every intelligent man and woman the whole world over, I feel that the honor conferred by my election to the Presidency of this section of the Australasian Association for the Advancement of Science arose from a desire to acknowledge the good work achieved by the Victorian Branch of the Royal Geographical Society of Australasia, rather than from any special personal fitness for the position. It was a stern sense of duty alone that induced me to accept the onerous task now before me, engaged as I am in active business pursuits. The terrible wave of commercial depression which all the colonies have to a greater or lesser degree experienced of late has left me but little time for thinking out and preparing an address worthy of this occasion. On that ground, ladies and gentlemen, I ask your kind indulgence for the many shortcomings in my attempt to add something to the sum of human knowledge on the important subject of geography.

There is power in union, and through the medium of this Association, which is a union of scientists throughout Australasia, we may hope to promote geographic research and to spread a knowledge of the results of exploration over a wider area than could otherwise be accomplished. Through the same medium we may also hope to awaken fresh interest in the exploration and geography of our own continent, and of the still unexplored regions of the Antarctic Ocean. I propose—

Firstly. Answering the question, “What is geography, its scope, and the advantages of geographical education?”

Secondly. To note the advance made in geographic research, and the geographical distribution of man in his progress towards civilisation.

Thirdly. To speak briefly of cartography, with special reference to Professor Dr. Penck's proposal to construct a colossal map of the world on a uniform scale; the geographical, commercial, and educational value of such a map, and the necessity for completing the topographical and geological surveys of the whole of the Australian Colonies.

Fourthly. To touch on geographical discovery and exploration, and the importance of photography in its relation thereto.

Fifthly. To suggest fields for future exploration.

WHAT IS GEOGRAPHY?

In an address delivered by Mr. J. H. Mackinder, B.A., in 1877, before the Royal Geographical Society of England, he puts the above question, and he proceeds to reply to it thus:—"There are at least two reasons why it should be answered, and answered now. In the first place geographers have been active of late years in pressing the claims of their science to a more honored position on the curriculum of our schools and universities. The world, and especially the teaching world, replies with the question, 'What is geography?' There is a touch of irony in the tone. The other reason is that for half a century several geographical societies have been active in promoting the exploration of the world. The natural result is that we are now near the end of the roll of great discoveries. The polar regions are the only large blanks remaining upon our maps. A Columbus can never again discover another America, nor a Stanley reveal another river like the mighty Congo to the delighted world."

That no doubt is true, but there yet remains a large amount of work for geographers in New Guinea, in Africa, even in Central Asia, in the North and South Polar regions, as well as in Central Australia. For many a year to come a Tasman, a Cook, a Greely, or a Nansen will now and again arise to show that the race of heroes in discovery has not become extinct. Still, as tales of geographic adventure grow fewer and fewer, even geographical societies may despondently ask, "What is geography?"

Geography, as I understand it, is a complete and systematic knowledge of the science which treats of the world, describing the earth, its physical structure and characteristics, natural products, political divisions, and the people by whom our globe is inhabited. Geography, therefore, viewed from its scientific side, is something more than committing to memory the names of places and lines laid down on the maps and globes.

SCOPE OF GEOGRAPHY.

In our Australian Colonies, at least, the true scope and aims of geography as a science are still very far from being properly understood. It has been aptly said "that geography is the central

sun round which the other sciences circulate, like so many contributory planets."

It would be difficult, indeed, to say what geography does not include, since a description of the earth would be incomplete without a knowledge of the elements of which it is composed; of its natural features, climates, and products; the different races of beings by whom it is inhabited, and of the part which these have played in the past history of the earth.

I am far from wishing it to be understood that an accurate acquaintance with all the details of each particular science is necessary to the right conception and comprehension of geography, but it is, I think, self-evident that any system of geography worthy of the name must embrace a general view of the other sciences with which it is so intimately allied. In Germany and Austria this comprehensive view of geography is now fully recognised, and there it ranks much higher in the educational system than it does in any other part of the world.

It has been said that geography covers so great a variety of departments of natural science that it really can call none its own. Geologists have taken possession of the modifications of the earth's surface, meteorologists lay claim to the science which treats of the atmosphere and its phenomena, and among the other sciences there seems little left to the geographer.

The late Professor Green, in his "Short Geography of the British Islands," even maintains that "history strikes its roots in geography, for without a clear vivid realisation of the physical structure of a country the incidents of the life which men have lived in it can have no interest or meaning. Through history, again, politics strike their roots in geography, and many a rash generalisation would have been avoided had political thinkers been trained in a knowledge of the earth they live in, and of the influence which its varying structure must needs exert on the varying political tendencies and institutions of the people who part its empire between them."

Precise observation has now supplied satisfactory proof that the earth's surface, with all that is on it, has been evolved through countless ages by a process of constant change. Those features that at first appear most permanent, yet in detail undergo perpetual modification, under the operation of forces which are inherent in the materials of which the earth is composed, or are developed by its movements, and by its loss or gain of heat.

The highest mountain which rears its lofty crest is slowly but surely being thrown down; the sternest, most impregnable rock which frowns above the sea is gradually being worn away by that insidious enemy; the deepest waters, the widest oceans, are unceasingly being filled up. The destructive agencies of nature are in never ceasing activity; the erosive and dissolving power of water in its various forms, the disintegrating forces of heat and

cold, the chemical modifications of substances, the mechanical effects produced by winds and other agencies, the operation of vegetable and animal organisms, and the arts and contrivances of man, combine in the warfare against "what is."

But hand in hand with this destruction—nay, as a part of it—there is everywhere to be found corresponding reconstruction, for untiring nature immediately restores that which she has just destroyed. If continents are disappearing in one direction, they are rising into new existence in another. Though the great sea wears down the cliffs against which it beats, the earth takes its revenge by upheaving the ocean bed.

The duration of the successive ages of the earth's past existence is measured almost wholly by reference to the fossil remains of animals and plants found embedded in the rocks of which its crust is composed.

The recent highly important discovery of fossil bones at Lake Mulligan, in the colony of South Australia, will be of great scientific value, exceeding as it does in magnitude and variety any other of a like nature hitherto made in Australia.

It is through the facts of geography as now known and interpreted that the geologist and zoologist are enabled to understand the true signification of much that has occurred in the past, the traces of which survive in physical features or organic forms. He finds that the most important agencies in determining and modifying the present conditions on the earth, whether as affecting inorganic nature or organic beings, are closely connected with the actual distribution of land and sea, and in the configuration of the surface learns that it is through these agencies that he must seek to unravel the intricacies of the long past.

In its turn, geology throws a light on much that would be otherwise unintelligible to the geographer. It teaches him how the boundaries of the sea and land have been determined, where former connections have been severed, how islands have risen from the ocean, and how even continents may have sunk below it.

The Most Honorable the Marquis of Lorne, in his presidential address, delivered at the anniversary (1888) meeting of the Royal Scottish Geographical Society, remarked "that if the noblest science among us is the knowledge of man, we may claim that we work to raise man to a higher level in making each life an aid for the advance of all. Each individual's devotion helps the second noblest science when his effort is directed to a knowledge of the features of that earth God has given to be shared among us, in proportion as we use the talents of courage, enterprise, and patriotism."

GEOGRAPHICAL EDUCATION.

To the Australasian Colonies the study of geography is of especial importance, and it comes home to each and all of us in a way that

could hardly be the case in other countries, where almost every problem connected with the commercial, industrial, and physical aspects of the science have been long mastered and understood. But in these lands geography is a nascent science. We have still vast areas in our own continent, as well as in New Guinea and the islands of the Pacific and Antarctic Seas, that are either wholly unexplored or so imperfectly known that stores of interesting and invaluable information await the explorer who brings to his task, not only the energy and endurance which so many of his predecessors have displayed, but that practical knowledge and grasp of the relative importance of things to be observed which only a scientifically trained mind can ever hope to acquire.

Lord Napier, of Magdala, speaking at the Exhibition of Appliances used in Geographical Education, pointed out "the importance attached to such education. Every trained soldier in the German army was provided with a map of the country," and to this he attributed "the great advantage of the German over the French in the Franco-German war."

Through the wise liberality of the Royal Geographical Society of England in offering prizes for proficiency in geography, no less than 3,237 male and female students presented themselves from forty-four training colleges for examination in 1887. Of these, Her Majesty's Inspector reports that 534 male and 576 female students passed in the first division, and 698 male and 1,139 female students in the second division; there also passed, in the third division, 149 male students and 189 female—a very successful beginning of a highly important, but hitherto much neglected, branch of education. It is also a very significant fact that in every division the greater number of students were women.

To the practical mind, whether he aims at distinction in the State or at the amassing of wealth, a knowledge and study of geography is a store of invaluable information; to the student it is a stimulating basis from which to set out along a hundred special lines; to the teacher it is an implement for the calling out of the powers of the intellect—unless, indeed, we except that old-world class of schoolmaster, who measures the disciplinary value of a subject by the repugnance with which it inspires the pupil.

The geographical descriptions now accessible in print are, to use a mild term, old fashioned. Where newer material has been published it is but fragmentary at best, brief, and imperfectly illustrated. The first elements of geographical study—the physical features of the earth—still call for close investigation.

THE PROGRESS OF GEOGRAPHY.

Sixty-three years have elapsed since the institution of the Royal Geographical Society of England—on the 24th of May, 1830. Before that time geographical science was practically unborn. At its inaugural meeting the President, Mr. John Barrow, in his

opening address, observed "that among the numerous literary and scientific societies established in the British metropolis one was still wanting to complete the circle of scientific institutions, whose sole object should be the promotion and diffusion of that important and entertaining branch of knowledge—geography."

During the past five years at least fifteen new geographical societies have come into existence. The number of members of geographical societies in 1892 was 52,800. France heads the list with thirty-one societies and 18,630 members; Germany stands next, with twenty-three societies and 8,960 members; the British Empire (exclusive of the Australian Colonies) numbers twelve societies and about 8,100 members, of which the parent society claims no less than 3,191; Russia follows, with eight societies; Switzerland takes the fifth place, owning six societies and 1,788 members. In Australia we have four societies or branches; and, although we cannot claim a numerous body of members, let us hope that the rising generation of Australians, as well as their fathers—to say nothing of the women of South Australia and New Zealand, whose political rights have been justly recognised by Parliament—will, when the present commercial and industrial crisis has passed away, feel it to be a duty and a privilege to keep alive the interest already created in geographical and maritime discovery, more especially in regard to Australasia.

An interesting volume was published in 1891 (report on the scientific results of H.M.S. *Challenger* during the years 1873-6).^{*} During the seventeen years that have passed since that report was written the subject has gradually evolved from small beginnings, and its latest developments are to be seen in the volume referred to, which, in point of interest, is second to none of the long series containing the results of that memorable voyage. The volume opens with a brief historical sketch of the progress of our knowledge of oceanography in general, or, as the Americans term it—and I think rightly term it—the geography of the sea, and of the materials composing the sea bottom in particular.

Another valuable book, entitled "Deep Sea Soundings," which is a brief account of work done by the United States steamer *Enterprise* during the years 1883 to 1886, has just issued from the press.[†]

Of the importance of such works to the whole scientific world it is quite needless to speak. They form a rich storehouse of facts which cannot be neglected by those who study either the history of the earth in the past, and the changes which are taking place on it at present, or the general biological problems involved in the relation of marine animals to their environment.

American explorers have sounded the depths of the ocean and discovered mountains and valleys beneath the waves; they have

^{*} Deep Sea Deposits, by John Murray, LL.D., and the Rev. A. F. Renard, LL.D.

[†] Deep Sea Soundings, by Captain A. S. Barker, U.S.N.

found the great plateaux on which rest the cables that bring us into instantaneous communication with the whole civilised world; they have shown the probable existence of a vast submarine range of mountains extending nearly the entire length of the Pacific Ocean—mountains so high that their summits rise above the surface of the sea to form islands, abysses so deep that the powerful rays of the sun could only feebly penetrate to warm or illuminate.

The exploring vessels of the American Fish Commission, in one single season, have discovered more forms of life than were found by the *Challenger* expedition in a three-years' cruise. They have shown that an acre of water may be made to produce more food for the support of man than ten acres of average land, and have thus thrown open to cultivation a territory of the earth constituting three-fourths of the entire surface of the globe.

America also claims to have led the way to and laid the foundation of a geography of the air greater in extent than all the oceans and all the land combined. Explorers in this branch of geographical science are now able to track the wind from point to point, and telegraph warnings in advance of the storm. A central bureau has been established in Washington, and an army of trained observers has been dispersed over all the world, and they observe the conditions of the atmosphere according to a preconcerted plan; the collocations of these observations give us a series of what may be termed instantaneous photographs of the conditions of the whole atmosphere. From the co-ordination of these observations, and their geographical representations upon a map, we obtain a weather map of the world for every day of the year. By careful study of the past movements of the atmosphere, and from these observations, we shall surely discover the grand laws that control aerial phenomena. Already a useful, though limited, power of prediction has been obtained. Continued research will in the future give us fresh forms of prediction, and increase the value of this new branch of science to mankind.

During this present epoch many and valuable additions have been made to our knowledge of the ocean, its depth, its temperature, the winds and climates that prevail over its various portions, its currents, and the life with which it abounds. Much of the information thus acquired has supplied completely new and wholly unexpected data upon which to deal, in our endeavors to interpret the earth's history and to understand the phenomena it presents to us.

GEOGRAPHICAL DISTRIBUTION OF MAN IN HIS PROGRESS TOWARDS CIVILISATION.

The geographical distribution of life and the geography of man is another important branch of the science, which time will not permit of my entering upon at any length.

From the days of Plato to Donnelly we have heard, at intervals, of the buried Atlantis; Dr. Bowdler Sharpe has now brought forward a formidable rival to it in the South Seas. Lecturing at the Royal Institution on the geographical distribution of birds, he suggested "that there once was a great continent, with its centre at the South Pole, now submerged under 2,000 fathoms of water. It embraced," he said, "New Zealand, South America, Madagascar, Mauritius, and Australia; thus is explained the existence of the cognate struthious (wingless) birds that now exist, or did once exist, in these countries."

That great changes have in past ages occurred, and are still taking place, must be evident to every student of nature.

General Strachey, R.E., F.R.G.S., late President of the Royal Geographical Society of England, in his fourth lecture on geography, delivered before the University of Cambridge in 1888, says—"Of the origin of life, either when or how it began, we know nothing; all that can be said is that the earlier conditions of the earth were altogether incompatible with life as we know it. For ages, as the globe cooled down, its surface must have been deluged with boiling water, and, until a temperature had been established not very greatly exceeding the present, none of the forms of life found in the lowest fossiliferous rocks could have come into existence."

The opinion that life originated in the North Polar regions, where the gradually cooling globe must first have reached a temperature in which it became possible to live, was, I think, first expressed by Buffon. There are indications, considered valid by competent authorities, that it was around the North Polar area that both vegetable and animal life were in the first instance developed, and thence disseminated over the rest of the earth. Within this area have been found representations of all the principally known fossiliferous systems, containing the remains of plants and animals closely resembling the present inhabitants of far lower latitudes, and even of tropical climates. Thus, in lat. 82° N. Silurian rocks exist, containing corals such as are to be now found under the equator in water of a temperature of 70° to 85° Fahr. In other localities, within 10° of the North Pole, remains of deciduous trees, similar in all respects to those now growing in warmer temperate regions, have been discovered.

Until about the middle of the present century both man and the world were popularly supposed to be about 6,000 years old, or, according to Jewish chronology, 5,654 years on the 12th of this present month (September, 1893); but during the last fifty years the discoveries made by Egyptologists, and the excavations of buried monuments of Assyria, Arabia, Phœnicia, and recently in the valley of the Mississippi, and the bringing to light of hieroglyphics, inscriptions, and fossil remains on our planet at an epoch almost inconceivably remote from our own; the discovery of a human skull

at a depth of 153ft. in the auriferous gravels of California, with remains of the mastodon, and covered by five or six beds of lava, or volcanic ashes; the fossil man of Denise, in the Auvergne, mentioned by Sir Charles Lyell; neolithic implements found with the skull discovered by Professor Cocchi, at Olmo, near Arezzo, and many other like discoveries, have combined to shatter all the old systems of chronology, and to put back the appearance of man on the globe to the tertiary period of its development.

In the valley of the Nile fragments of pottery have been brought up from depths indicating an antiquity of at least 11,000 years, while other remains are conjectured to have belonged to an epoch separated from our own by an interval of not less than 26,000 years.

That man was the contemporary of many extinct animals, at a time when the configuration of land and sea and the conditions of climate were wholly different from the present state, there can be no doubt; and modern research has done much to show how our race has been advancing towards its condition of to-day during a series of ages, for the extent of which a geological rather than an historical standard of reckoning is required.

The facts thus brought to light have, in recent years, given a different direction to opinion as to the manner in which the great groups of mankind have become distributed over the areas where they are now found; and difficulties once considered insuperable are easily overcome, when regarded in connection with the now ascertained extreme antiquity of the human race and those great alterations of the outlines of land and sea which are shown to have been going on up to the very latest geological periods.

What were the stages through which primæval man passed in acquiring his present place in the advancing front of living creatures will probably never be more than a matter of speculation. The progress of the human race towards civilisation has been controlled in all directions by the features and conditions of the earth's surface. The climate, temperature and moisture, succession of seasons, length of day and night, have gone far in determining the physical characteristics, the bodily strength, and the duration of life in various races, and as less direct consequences and under the greater or smaller need for the exercise of forethought in providing against vicissitudes of existence, have been developed their several capacities, social and intellectual, their numbers, wealth, and power.

With all his arts man remains subject to the irresistible power of terrestrial conditions and geographical influences. History tells us how, under the influence of causes that can be traced back to the material earth, the destinies of our race have been determined, nations have been born, have grown, have flourished, and have perished; for whether we call it mother-country or fatherland the soil under our feet, as in the Greek fable, is the true source from which we draw our bodily, mental, and social strength. A know-

ledge of the relations that subsist among living beings, which is a direct result of geographical discovery, shows us man's right place in nature.

The accumulation of knowledge from other countries of various forms of life, and of the different conditions under which they are found, could only have been obtained by means of geographical exploration; and it was this, without doubt, that rendered possible the remarkable generalisations of Darwin and Wallace as to the origin of species.

CARTOGRAPHY.

With special reference to Professor Penck's proposal to construct a Colossal Map of the World, &c., &c., &c.

When Joshua divided the Promised Land among the twelve tribes, minutely describing their respective boundaries, we can hardly conceive that he did so without the aid of a map of some kind. It may, therefore, be taken for granted that maps have existed from very early times. The only document of the kind which has come down to us (and that in fragments) is a map of ancient Rome, engraved on slabs of marble originally fixed into one of the walls of the Forum.

The proposal of Professor A. Penck to construct a colossal map of the world, on a uniform scale of 15·78 (or about 16) miles to the inch, has been recently submitted to an international committee of about twenty-five cartographers to concert measures and frame regulations for its execution.

Some idea of the magnitude of the work may be gathered from the following figures:—Area of paper required, 1,000 sheets 14in. x 18in.; cost of drawing, lithographing, and printing each sheet in six colors, on six separate stones, £100 per sheet. Total cost of the complete map, £100,000. At the Paris (1889) Exhibition, a globe 42ft. in diameter, $\frac{1}{1,000,000}$ of the diameter of the earth (the scale of Dr. Penck's map) was exhibited, the surface area of which was 5,500 square ft.

The advantages of a map of the whole world on a uniform scale must be evident to all. A survey of Australia mapped on the scale indicated would be a grand work, and well worthy of the attention of all geographers. A general map of the world on the same scale would mark an epoch in the history of cartography, and confer incalculable benefits on geography. The large map of Australia now before you on the wall is on a scale of twenty-six miles to 1in. On the colossal scale proposed the Australian Continent would cover a sheet two-thirds larger.

A new and carefully revised edition of this map of Australia, with additions and numerous corrections, and showing the latest geographical discoveries, is now being compiled by A. J. Skene, M.A.,

late Surveyor-General of Victoria, whose map of continental Australia, published in 1887, is well known. This new map it is proposed to publish under the auspices of the Victorian Branch of the Royal Geographical Society of Australasia, of which Mr. Skene is a member.

GEOGRAPHICAL DISCOVERY AND EXPLORATION, AND THE IMPORTANCE OF PHOTOGRAPHY IN ITS RELATION THERETO.

Now that the more important geographical features of the Australian Continent are known, the necessity for correct topographical and geological surveys are becoming every day more and more apparent. A topographical map, showing a correct delineation of the surface features of the country, is a fundamental necessity for the geological surveyor; the localities where mineral substances of value exist, the soils suitable for agriculture and horticulture, and the facilities for water storage and irrigation clearly indicated; in short, topography is to the geologist what anatomy is to the surgeon and physician.

In a paper read a short time ago by Mr. James Stirling, F.G.S., of the Geological Survey Department, before the Institute of Surveyors at Melbourne, that gentleman urged, in the interest of the miner, the agriculturist, the civil and hydraulic engineer, the duty of the Victorian Government to complete the topographical and geological surveys of the colony. The suggestion is a valuable one, and should be acted upon by the Governments of all the Australian Colonies.

The growing importance of photography in its application to science, notably to geography, is a matter of congratulation. Every explorer should avail himself of the great advantages that a knowledge of photography secures in enabling him to illustrate his route, register his observations, portray with scientific accuracy the visible objects, topographical and otherwise, met with in his travels. Until very recently the work was done by pen and pencil. The most finished illustrations, though they had a more or less amount of truth, were often obscured by some personality which rendered them valueless, or even misleading; but no one will deny that it might have been more satisfactorily accomplished by well-executed photographs.

It is not possible to portray with any degree of accuracy, or to illustrate and describe in a perfectly realistic manner, scenes and incidents by the way, so as to render them of permanent value, without the aid of the camera. The series of photographic views taken by the Elder Scientific Exploring Expedition will be of great interest for all time, and it must be admitted that in no other way could true pictures of the country traversed have been conveyed to the general public.

FIELDS FOR FUTURE EXPLORATION.

To all who take an interest in the history of the human mind, and the development of human enterprise, geographical science and geographical discovery must be deeply interesting. We can but faintly picture to ourselves the feelings of Columbus when he first caught a glimpse of the islands of the Western World; of Tasman, as he beheld the rugged coast of Van Diemen's Land, and the lofty snow-crowned mountain peaks of New Zealand; or of Cook and Flinders when they sailed along the coast of Australia, with its ever-varying scenery. What intense satisfaction and pride must have filled the heart of Governor Phillip, who first discovered the beautiful valley of the Hawkesbury; of Hume and Hovell, when, during a long overland journey, they successively discovered the Murray, the Ovens, and Goulburn Rivers, and the placid waters of Corio Bay. How impossible it is for us to fully realise the emotions of our Australasian explorers—Eyre, Light, Sturt (the recollection of whom should inspire the present generation), Gregory, Giles, Stuart, Lindsay, Sir Wm. Macgregor, and other heroic explorers who, in their turn, have revealed the existence of important rivers, lakes, and mountains in Australia, New Zealand, and New Guinea.

The fact, humiliating to our pride as geographers, must be admitted that altogether apart from the North Polar and Antarctic regions, a great amount of further research has to be undertaken before our geographic knowledge can be said to be complete. When we embark on the vast ocean of discovery, the horizon of the unknown recedes and surrounds us in whatever direction we go. The more knowledge we acquire, the greater becomes the sense of our ignorance. Notwithstanding the increased facility for solving the geographical secrets of the globe placed within the grasp of man during the present century by the steam-engine, the printing press, and electricity, the civilised world knows comparatively little about the centre of Africa, the great watershed of the Amazon River, in South America, where there are tracts as large as the whole of France of which we know less than of almost any equal area on the globe (tribes of men are living there who are yet absolutely in the Stone Age, and who, even by barter or distant rumor, never heard of the European race or the use of metals), the great tablelands of Asia, the interior of New Guinea, a large portion of the interior of Australia, or even the beautiful islands that stud the Pacific Ocean. We live in an age of feverish excitement and persistent toil, and yet years must pass ere the contradictory statements of explorers shall have been satisfactorily explained. Much patient labor must also be endured before the climate, hydrography, botany, zoology, commercial resources, and capabilities of these unknown regions can be thoroughly familiar to us.

To fully elucidate the gradual changes in the aspect and physical phenomena of many parts of the globe, minute and systematic

researches have to be conducted, while the greatest caution has to be exercised to differentiate between those changes arising from the spontaneous action of nature and the changes produced by human agency. A knowledge of all these facts of science must be acquired before we can boast that we know all about the globe we inhabit. At present we are but standing on the threshold of this great knowledge. The full accomplishment of the task will be the heritage of future generations, "when fellow-workers from all parts of the globe will meet to write the grand book embodying the sum of human knowledge." Upon scientists in Australasia devolves the duty of collecting some of the data for that book, and I cannot therefore conclude without asking the members of the Australasian Association for the Advancement of Science to mark the large area of the earth's surface that lies so near at hand, and which presents a virgin field for exploration and scientific investigation, namely, the region encircling the Antarctic pole.

It is now more than eight years since that leader among botanists, Baron Sir Ferdinand von Mueller, reawoke the mind of the scientific world to the need for following up the discoveries of Captain Jas. Clarke Ross, R.N., in the vicinity of Victoria Land; and simultaneously my attention was called to the important question of Antarctic exploration by a lady present at this meeting, who, when a girl, stood on the decks of the *Erebus* and *Terror* on their return to Hobart. Under that impulse,* the Councils of the Victorian Branch of the Royal Geographical Society of Australasia and the Royal Society of Victoria appointed an Antarctic Committee, to act in conjunction with the societies in the other colonies, for the purpose of raising a fund to fit out a scientific expedition, and to arouse public attention, both in Australasia and Europe, to the valuable sources of national wealth which such an expedition would reveal by the discovery of whaling and sealing grounds in the Antarctic seas. Nor has this committee (of which Commander Pasco, R.N., F.R.G.S., is president, Mr. G. S. Griffiths is an enthusiastic member, and the Rev. W. Potter, F.R.G.S., hon. secretary) ever flagged in prosecuting the work assigned to it. In compliance with an offer made to the committee by Barons Nordenskjöld and Dickson, a Swedish-Australasian Scientific Antarctic Exploring Expedition was projected, and several subscriptions to the expedition fund were promised, notably one of £5,000 from the great South Australian Mæcenæ. Owing, however, to the severe commercial depression, already alluded to, only a very small portion of the Australasian subscriptions were paid into the Antarctic Committee by the end of 1892, and consequently Barons Dickson and Nordenskjöld withdrew their offer of co-operation, and the project of a purely scientific expedition has had to be abandoned, for the

*The owners of the four vessels which formed the Antarctic sealing fleet, at a meeting held in Dundee yesterday, agreed to form a limited liability company with a capital of £60,000.—*The Dundee Advertiser*, Wednesday, July 5th, 1893.

present at least. But the labor of the Antarctic Committee has been far from futile. Immediately upon its creation it placed itself in communication with the heads of the Arctic whaling firms in Great Britain, and also with the Antarctic Committee of the British Association for the Advancement of Science, and pointed out the inducements for steam whaling ships to visit the Antarctic on Australian longitudes. This action of the committee it was, no doubt, that led to the commercial enterprise of the *Balaena* and other vessels which last year sailed from Europe for the Antarctic upon American meridians, all of which vessels returned this year richly laden with seal oil and seal skins, although not having discovered the coveted "right whale." It is more than probable that the Antarctic Committee will by next season be able to induce some of the whaling firms to send their ships out on our longitudes. One of the Norwegian firms has, I understand, already intimated to the Government of Victoria its willingness to send out some of its best steam whaling ships to operate in the vicinity of Victoria Land if a small subsidy can be obtained. Would it not be well, then, if this Association were to co-operate with the Antarctic Committee, and address the several Australasian Governments upon the subject? In addition to the commercial advantages to be gained, there are various important scientific problems that need solution, and which it would redound to the honor of this Association to assist in solving. With the revival of commercial prosperity, the Antarctic Committee may hope to succeed in raising the necessary funds for an expedition, more especially if Sir Thomas Elder can be induced to make good his promise to the Committee.

In the cause of science, which is cosmopolitan, and in the carrying out of a project so pregnant with scientific and commercial good to Australasia, all local feeling and prejudice should be cast away. Let us see to it that the glory of making discovery and explorations in these Southern Seas be not borne from us by others, to our everlasting discredit.

In conclusion, I desire on behalf of this Association to recognise the patriotic and munificent assistance rendered by the Honorable Sir Thomas Elder, K.C.M.G., F.R.G.S., to the cause of Australian exploration, by the equipment and dispatch of several expeditions into the interior of our Continent, especially those under the leadership of Ernest Giles, F.R.G.S., in 1875, and David Lindsay, F.R.G.S., in 1891, and last, but not by any means least in point of scientific interest, the dispatch of teams to bring down fossil remains of extinct animals lately discovered at Lake Mulligan. The noble generosity displayed by Sir Thomas Elder in thus aiding geographical and zoological research reflects the highest credit upon him personally, and also upon the Colony of South Australia, with which he has been so long and so honorably identified.

Section F.

ETHNOLOGY AND ANTHROPOLOGY.

ADDRESS BY THE PRESIDENT,

REV. S. ELLA.

THE ORIGIN OF THE POLYNESIAN RACES.

At the several Sessions of the Australasian Association for the Advancement of Science it is gratifying to observe that the Anthropological Section has commanded a large amount of attention, and our meetings in the different colonies in which they have been held have attracted a good attendance, and the audiences have always manifested deep interest in the proceedings. Many of the matters brought before them were, indeed, of much interest and of considerable importance, especially to the intelligent student of anthropology. Much valuable matter has been collated, and fresh facts of vast significance have been brought before us by gentlemen whose knowledge and experience of the subjects stated entitle them to respectful attention. Indeed, the only disappointment felt was that more papers of the character were not forthcoming and a more extensive and fuller collection of facts placed before the anthropologist, to satisfy the craving of his mind and the desire of many others for reliable information on the subjects of ethnology and comparative philology.

Anthropology opens up a large field of investigation and discovery in the various branches connected with the study—in ethnology, archæology, history, and philology. There is connected with each so vast an area that, with the intelligence already established and knowledge yet unrevealed, or but dimly perceived, the most ardent and ambitious student may feel assured that there stands before him much ground to be explored and a most inviting field for investigation. not so much for the solution of sundry hypothetical theories as for the unearthing of stores of scientific wealth in the regions of anthropology. There is enough information gathered, and much more as yet unknown, to stimulate and encourage the earnest student in any one of these branches. Each fresh discovery, every new fact, and even unproved theory, stimulates and encourages wider inquiry. Each becomes a stepping-stone to cross to more substantial ground. The student may safely leave alone some interminable and unsatisfactory speculations which

have been advanced by writers who have theorised without sufficient authority, for there are ample facts fully established to guide him in his pursuit of knowledge. The efforts of the student should be directed by a clear, patient, and persevering research. He should carefully avoid being misled into a labyrinth of vague conjectures, by which the truth often vanishes from the grasp.

The Polynesian Islands afford a large field for anthropological study and research, and a grand discovery will be made when it is elucidated whence their inhabitants came, and how they made their way to this part of the world. We in Australasia have not only a more intense interest in these people, but also far better means and opportunities for settling questions regarding them, than they possess who are at a greater distance from these islanders. No time should be lost in following up the inquiry. The data obtained in the discoveries already made are so many landmarks of essential value to the explorer in reaching regions not yet explored. The time favorable for the acquisition of positive knowledge of the races of Polynesia is fast slipping away, and ere long it will be too late to gather up facts now existing but gradually vanishing into obscurity. It is a fact that must not be lost sight of that the lapse of time is obliterating many sources of information which might have afforded valuable aids in the investigation. In many islands and groups the progress of civilisation is changing entirely the former customs of the aborigines, and blotting out the memory of their ancient traditions and legends. A generation has grown up who are utterly ignorant of the ethnology of their forefathers, and who possess but a very slight acquaintance with their myths and legendary lore. Foreign residents, missionaries, and others at the present day experience much difficulty in obtaining intelligence of the native customs and mythology from the natives themselves, and reliable information can be procured from the old people alone, and these are becoming fewer and fewer, and ere long they will have passed away. Missionaries, too, who took an interest in the study of these subjects, and who by familiar intercourse with the natives during a long residence among them when in their primeval condition, are likewise moving off from the active stage of the world. Some have passed away without leaving a trace behind them of the knowledge they had acquired, not considering its importance to future generations in the advancement of scientific truth. It is greatly to be regretted that valuable documents of deceased missionaries have been lost through the indifference of surviving relatives. Some of these were orderly compilations of facts, others little more than unconnected *notanda*, all more or less useful had they been preserved. There is a question I would earnestly submit to the members of this Association, especially to those interested in the subjects of this section, and urgently press on their intelligent attention, viz.—*Can a satisfactory solution be obtained regarding the origin of the Polynesian people?*

In placing before you this question I am not making any new suggestion. The inquiry has already exercised the minds of many intelligent ethnologists. Some have given considerable attention to the subject, and have attempted, to a certain extent, to elucidate the theories which they have formed. In 1834 the late well-known divine and historian, Dr. John Dunmore Lang, of Sydney, published a work which has been read and pondered with much interest, although it gives but little satisfaction as regards the origin of the Polynesian natives, for the reverend doctor's statements are mostly hypothetical and unsupported by historical facts. One important theory the doctor seems to have established—that the original inhabitants of Polynesia came from the west by way of India, and not, as many supposed, from the east by way of America. Dr. Lang's book may be recommended as a help in following up the inquiry to a more positive and definite issue.

At the first meeting of the Australasian Association, held in the Sydney University, Dr. Carroll read a very long paper, containing much historical information, in which he attempted to associate the progress of the races from Asia to Polynesia with the march of conquering armies from the Euphrates on to the Malay coasts. But this paper, however deeply interesting, as it was, and supported by historical records, satisfied only to a partial extent, that is as far as the historical data proceeded, but beyond that seemingly there were only vague suppositions to supply the place of substantial facts.

It will be readily admitted by all who have given attention to the inquiry that the investigation is by no means a hopeless one, though surrounded by difficulties. A few landmarks may now be found, although separated by long distances. The lapse of time may have obliterated some which were plainly visible in former ages. The evidences of their existence at one period, though partially obscured, are not entirely and irrecoverably lost; and out of the remaining vestiges there may be revealed some authentic data which will lift the inquirer to a more solid and secure basis, and clear away much of the mist which vague theories have created in the mind, and also dissipate the confusion occasioned by opposite opinions and arguments. Diversity of opinion will exist in proportion to the want of positive and scientific knowledge.

A large amount of information has been supplied from various sources and by writers whose authority may be safely depended upon. Their contributions may be collected by a diligent student, and comparisons made that will enable him to form a corollary of evidences, and a clear and faithful method of tracing what is evident will help in discovering what is out of sight. Difficulties, indeed, may be experienced in defining what may appear to correspond, but patient and painstaking study will help the student to distinguish the correlative from the diverse. Profitable and reliable research must be made with a clear unbiassed mind, free

from prejudice and hasty conclusions, and, above all, free from any favored theory of our own conception or misleading theories advanced by others. We shall find ourselves on a dangerous road, which will undoubtedly lead us astray, if we start with a pet supposition, and seek to bend facts to support a mistaken theory, and deem such warped facts as truths and evidences.

The tastes and proclivities of students vary, but each will find abundant scope to exercise his mind and direct his study of anthropology in its several phases of genealogy, ethnology, archæology, and comparative philology; and each may work towards a solution of the question here proposed regarding the origin of the Polynesian people—Whence they came and what directed their various migrations? It is difficult to conceive that the various islands were entered and populated by series of accidental circumstances of waifs and castaways, as some have supposed. Settlements have been made by large numbers at different periods. We find the Indo-Polynesian races occupying large territories and forming distinct nationalities in certain groups of islands, and Melanesian races possessing other groups; and in some countries, as in New Guinea and the Fiji Islands, the two races commingling or preserving distinct boundaries. In Eastern Polynesia—from Tonga to Easter Island and from New Zealand and the Paumotu Archipelago southward to the Sandwich Islands northward—the Indo-Polynesians hold possession of the entire area, covering some thousands of square miles. Then, again, north-west to the Caroline Archipelago the same race prevails, and are found in like preponderance in the Malay Archipelago. On some of the groups in the west, in the New Hebrides and other islands, this conquering race are found established in settlements which were evidently made long ages ago. In the western regions of Polynesia the Melanesian race prevails, under the form of what are denominated Papuans and Negritos.

Evidences have been obtained of the manner in which some Polynesians have been carried to islands at considerable distances from their native lands, and where they have settled among other races and maintained their distinctiveness for several generations. I may mention some instances which have come under my own observation. About forty years ago we discovered a tribe of Samoans occupying a district on the island of Efaté (Sandwich I.), in the New Hebrides Group, with whom easy intercourse was held through the medium of the Samoan language. The account of their immigration was to this effect: Before Christianity was introduced to Samoa, in one of their sanguinary conflicts, a canoe party effected an escape from the conquered district and fled to seek refuge in Tonga. Owing to adverse winds these natives missed their intended destination and were carried to the New Hebrides, and reached the island of Efaté. Here, after several conflicts with the natives, they were able to establish themselves. Many years afterwards they were visited by the missionary ship *John Williams*,

and some returned in that vessel to Samoa. The islands of Aniwa and Futuna, in the New Hebrides, are peopled by natives originally belonging to Tonga and Futuna proper, N.W. of Samoa, intermixed with natives of Tanna. Other islands in the group are inhabited by Malayo-Polynesians, probably from the east.

On the island of Iai (Uvéa), in the Loyalty Group, some castaways from Tonga and Wallis Island have long been settled, one party—Uvéans (Wallis I.)—occupying the northern end of the island, and the other on the southern extremity, which they call Tonga. The original inhabitants, Iaïans, occupy the central districts. A description given me by these, and also by some natives of the Union Group, in some measure accounts for the manner in which these waifs get driven away to distant islands. They were accustomed to move from one island to another, long distances apart, in their clumsy *prahs* in times of scarcity of food or other emergencies; and the night time, when the sea is calm and the wind light, was generally selected for these voyages. They steered by the stars, and if the night became cloudy, or an adverse wind arose, they would simply lower the sails, entreat the protection of the gods, and then quietly resign themselves to drift whither the sea and winds might bear them.

We have notices of two instances of castaways which occurred last year. On the passage of the *Changsha* to China, in February, she picked up fifteen Malay castaways. Their food supply consisted solely of cocoanuts and a little water. When picked up the poor natives were huddled together in four junks. They had started from Amboina with a fleet of seventeen junks, and they had been thirty days knocking about at the disposal of the wind and the sea. During a gale thirteen of the junks went down. These survivors were landed by the *Changsha* at Amboina. In April the American mission vessel conveyed to their homes at Taputuea, in the Gilbert Group, a family of natives of that island, who had been carried away during a gale. They had gone out one night in a small canoe to fish; the wind came on to blow hard, and the canoe drifted out of sight of the island. They had neither food nor water in the frail canoe, while for forty days they drifted over the wild ocean. One of the four perished. At the expiration of those terrible forty days the canoe reached Ocean Island. The survivors stayed on Ocean Island some days, and were then taken by a vessel to the island of Annunçion. Then they were picked up by the *Morning Star* and conveyed to their home.

These instances will afford some evidence of the manner in which the islanders are often borne from their native lands by accident, and have found asylums in distant parts of the Pacific. Yet we cannot suppose that the various groups were occupied and populated under such distressing circumstances. The evidence is much clearer that the advance of the aborigines was made under voluntary influences and with settled designs.

Unfortunately, from the lack of historical records, and with only the dim light of native traditions, there is an insurmountable difficulty in defining dates and periods of native events. Take, for instance, the history of the New Zealanders. It is plainly seen that the Maoris were not the original inhabitants of New Zealand, and the question arises—Whence came they? and how was New Zealand occupied before the Maori incursion? Some aid to this inquiry will be found in the works of Sir George Grey and in Dr. Gill's Rarotongan Myths. The invasion and conquest of Chatham Island by a tribe of Maoris afford an instance of the way in which a superior race has subjugated a weaker and possessed its territories. The ancient Moriori of Chatham Island have been nearly extinguished by their savage conquerors. [Moriori, the name of the aborigines of Chatham Island. Perhaps the name "Maori" is a corruption derived from the original people of New Zealand so called.]

Notwithstanding the obscurity which now prevails, and the many difficulties that have to be surmounted in obtaining light and information to guide to right conclusions, I believe satisfactory answers to the questions will ere long be obtained. I desire now to stimulate students of anthropology in making investigation, and to help them in the inquiry. I am not sanguine enough to expect that all that is required will be effected at once, or by any individual student. It is a search in which several will have to start in different directions and meet together at a given point. Each may take the course which most suits his own taste and desire. The ways are open and lie directly before us—in history, genealogy, ethnology, folklore, archæology, and comparative philology. A few remarks here on each of these subjects may be helpful. Much information on all these subjects has already been published. What is now requisite is to follow up the inquiry, procure further information, and bring all into conjunction, with careful analysis and just comparison, and then that which now appears shrouded in mystery will be unravelled.

In history no direct unbroken chain has up to the present been discovered. There is, however, some isolated information that may be brought together which will enable the student to obtain a clue to the knowledge sought. Marsden's "History of Sumatra" and works of that order, will be found of great advantage. It will be well, perhaps, for the student, in the first instance, to direct his attention to the histories of India, especially those of the southern nations; then to what can be collected of historical records of the ancient peoples of South America, although regarding these the philosopher and historian, Dr. von Martius, despaired of obtaining any correct information. He says—"There is not a vestige of history to afford any clue, not a ray of tradition, not a war song nor a funeral lay can be found to clear away the dark night in which the earlier ages of America are involved." The mists of long ages,

once penetrable, have been left undisturbed, and now it may be too late to dispel them by any light which modern discovery may bring to bear upon them. But, remembering what recent discovery has done in revealing historical facts of ancient nations, we will not despair of revelations yet to be made in this direction. Humboldt's Researches offer considerable aid in reference to the ancient American nations, and have led some to identify them with the Polynesians.

Of genealogy there have been lately published some valuable records, exhumed from long hidden native traditions, myths, and legends. I may particularise those from Maoriland, Samoa, and the Hervey Group. Thanks to the transcribers of these, we have a chain of events that bears remarkable comparison, and are favorable to the formation of some links in historical evidences. The Rev. J. G. Lawes is collecting another fund of interesting information in New Guinea. I believe there is much light yet to be gathered in this direction, and I sincerely trust that every literary and intelligent resident in Polynesia will take every opportunity for searching for such intelligence as may be procured from the natives among whom he resides. Ere long the time for such research will be closed, and records be lost for ever. Facts of great value in the inquiry as to the origin of the Polynesian races will be found in native genealogies.

In ethnography some very interesting and valuable intelligence will be found in papers supplied to this Association, and published in its several volumes; but these comprise only a portion of information that may yet come before you in connection with this section of the Association. There is also a large amount of ethnological facts contained in various works of missionaries, travellers, and residents of Polynesia that will aid the ethnologist to trace a unity of origin in many distinct nationalities of the Pacific islands. Time will not allow of entering into details, or I might point out striking comparisons. I may say this, however: I am deeply impressed with the conviction that the native customs, manner of life, modes of government, &c., point to an oriental origin. The *Polynesian Journal* contains important and deeply interesting papers, which will be highly appreciated by ethnologists. I would call attention to the first article published in No. 1 of the *Journal* by Mr. Eldon Best, on "The Races of the Philippines." Wallace's "Malay Archipelago," though of most value to the naturalist, affords available facts also to the ethnologist, and it supplies aids for the investigation I have suggested. Ellis's "Polynesian Researches" is an old and valuable book, and the same author's work on Madagascar will be found of much use.

Closely allied to the study of ethnology is that of folklore, a subject of deep interest to many in Australia. Polynesian myths, legends, songs, and superstitions supply a large fund of folklore.

Comparisons in this direction will give some clue to the relationship existing among the various races of Polynesia. Records of folklore will be found in some books of travels and voyages, missionary works, and notices of native legends, &c. The late Rev. Thos. Powell made a large collection of these in Samoa, a portion of which has been published by the Royal Society of N.S.W. The Folklore Society of Great Britain is publishing *in extenso* all that is brought before it. One may discover a resemblance, if not an exact parallel, in Polynesian folklore to some well-known folklore of Scandinavian and Norman origin, as well as to many of the Hindoo, Japanese, and Malagasy contributions. An opinion expressed 300 years ago by the poet Edmund Spenser will denote the value of this study in elucidating the inquiry placed before you. He says, "By these old customs, and other like conjectural circumstances, the descent of nations can only be proved where other monuments of writings are not remaining."

A few monuments of archæological remains are found in the Pacific Islands, which may serve as landmarks denoting the advance of a people accustomed to erecting gigantic structures, either as temples to their deities or shrines for their dead—perhaps for both purposes. Some of these structures have a pyramidal form, some are stone terraces spreading over a wide surface, others are massive stone platforms, probably the base of a superstructure which has long since been destroyed. In certain places there are still found some colossal statues, hewn and sculptured with evidences of skill. The most remarkable of these, which have attracted the attention of travellers and others, exist on Easter Island. Similar structures were found on Tahiti, and in the Marquesas and other islands. Captain Cook was much struck with the gigantic statues on Easter Island, somewhat resembling Egyptian sphinges. The sculpture was rude, but not void of skill. Some of the figures stood in groups on massive platforms of stone, tenoned, but without cement. One statue measured 27ft. by 8ft. In 1868 one of these statues was conveyed to the British Museum, and weighed five tons. The platforms in some places contain inscriptions in hieroglyphics. In Mexico and Peru there exist remains of very ancient architecture of the same character, and the hieroglyphics have been translated and found to have reference to the worship of the sun and moon deities. The pyramids in South America were appropriated as burying-places of chiefs, and, so far as can be gathered from native traditions, these in Polynesia were used for a similar object. A platform of huge stones which I saw on the island of Manono, Samoa, was pointed out to me as the tomb of one of their old chiefs. The *teocalli* of South America evidently bear a close relationship to the *heiaus* and *maraes* of Eastern Polynesia and the *dubus* of New Guinea, and may also be considered as possessing some affinity with similar pyramidal constructions in China and India.

In the first number of the Journal of the Polynesian Society there is a description of one of these ancient structures, discovered by Mr. Handley Sterndale on the island of Upolu, Samoa. While rambling in the interior of the island he came to a lofty spur of a mountain, with a volcanic centre. He crossed several deep ravines, down which flowed mountain torrents. One of these ravines had been converted by the hand of man into a fosse. In some parts it was excavated, and in others built up at the sides with large stones, and in one place he found a parapet wall. He climbed up this gully, and passed through a narrow gap in the wall. Then he discovered on a level space before him a conical structure of huge dimensions, about 20ft. high and 100ft. in diameter, built of large basalt blocks, some of which he considered to have been about a ton weight; they were laid in even courses. In two places near the top he remarked what appeared to have been entrances to the interior. He entered a low cave or vault, choked with rock and roots of trees. He found appearances of narrow chambers within. Mr. Sterndale thought that this pyramidal structure at one time formed the foundation of some building of importance. Many other such foundations of 10ft. high were near it. He also observed a number of stone cairns, apparently graves, disposed in rows. There was also a paved court, or mausoleum, covered by a huge banyan tree, with a stone cromlech in the centre. Mr. Sterndale asks, "What manner of men could have inhabited the stronghold below, and have been laid to rest in this woodland necropolis?" and adds, "I am well convinced that these remains were the work of a people anterior to the existing race of Samoans. Their origin, like many other remarkable relics and ruins in the Pacific, is a part of the great mystery of the isles, *i.e.*, of the early distribution of man throughout the Polynesian archipelagoes." This philosophical remark accords with the opinion held by many anthropologists, that there were Polynesian races of very high antiquity. The investigation before us will, I firmly believe, open up a long vista of past ages, and reveal to us races of men occupying the isles of the Pacific long anterior to the races now found there. Without venturing an assertion, except upon more valid grounds than a mere supposition, yet I may suggest with some diffidence that these monumental structures of South America and Polynesia may have derived their origin from the temple of Belus in Babylon, and the gigantic tumuli of Lydia and Lycia in Asia Minor. The clay pottery manufactured in some parts of New Guinea, New Caledonia, the New Hebrides, and in Fiji bears some resemblance to the terracotta vessels of these countries.

The philological phase of anthropology we may consider as the most important and helpful factor in determining the question of the origin of the Polynesian races. It is gratifying to find that many philologists in Europe, America, and Australia are devoting

much time and earnest attention to the Oceanic languages, Indo-Polynesian and Melanesian. These tongues are numerous and diverse. Especially may this be affirmed of the Melanesian and Papuan races, among whom a perfect Babel of tongues may be found; yet even here some philologists have discovered a root language, and have traced to some extent the course of divergence. That which is commonly termed the Malayo-Polynesian is most readily reduced to its primary condition, and the various dialects of this language are spoken by the larger portion of Polynesian nations.

One of our members, Dr. John Fraser, of Sydney, is now engaged in a close analysis of some of the Melanesian tongues. Mr. Sidney Ray, of London, has labored for many years upon the same topic, and he has laid under tribute every South Sea missionary he has come across to supply him with the information which each possesses, and there are none so able to afford him the desired knowledge. There are many other philologists, like Dr. Max Müller, who are working in the same direction; some of them with the aim and purpose of fixing the origin of the Oceanic people in defining the origin of their language.

The Rev. D. Macdonald, of the New Hebrides, has supplied a valuable paper to the Polynesian Society on "The Asiatic Origin of the Polynesian Personal Pronouns" (*see Journal of the Society, December, 1892*). With careful comparison of different languages, he arrives at the conclusion "that the Oceanic pronouns are descended from one original, and that they represent the personal pronouns of the original Oceanic mother-tongue." After a clear and patient analysis of the Oceanic pronouns, Mr. Macdonald, with some ingenuity that arouses many questions, arrives at the roots of these pronouns, and then discovers that the same roots may be found in ancient Arabic, Himyaritic, Ethiopic of Abyssinia, Chaldaic, Hebrew, and Phœnician, and in ancient and modern Syriac. To illustrate intelligibly Mr. Macdonald's theory would require the use of his tables 1 to 8 and his explanations thereof. He concludes with the remark, which defines his position: "It seems sufficiently clear from the foregoing that the Oceanic pronouns are of Asiatic origin, and belong exclusively to the particular Asiatic family indicated." There may be room for difference of opinion as to this or that detail, but it seems sufficiently obvious that the Oceanic compares with the Asiatic.

Oceanic.			Asiatic.		
aho, ku	.....	compares with	ho, ku	—	I.
ik	.....	"	ika	—	thou
ni	.....	"	ni,	—	he (they)
ana	.....	"	na, nha, ahna	—	we
ituma, kemu	.....	"	atem, kemu	—	you
in, inia, nia	.....	"	(hem, hen) ani, ni,		
			(inun, inin)	—	they
ila, era	.....	"	ela, &c.	—	these, those.

Professor Bopp, of Berlin, recognises the relationship of the Oceanic tongues with the Malay, and traces these to Sanskrit originals. Another and more recent writer, Judge Abraham Fornander, of the Sandwich Islands, believes that the Malay words found in the Polynesian languages are a recent and accidental introduction, and that the root words of these languages can be traced to the Aryan family. Dr. J. Fraser, who has given considerable attention to Polynesian and Australian tongues, is of the same opinion with respect to the Aryan originals. Dr. Codrington's investigations will afford much light on these subjects. In some of the islands of the Indian Ocean the languages of the people bear a close affinity with those of Polynesia. This is observable in the Malagasy and in the tongue of the Weddahs, a primitive and wild tribe of Ceylon, now nearly extinct, whose language is pronounced to be a corrupt form of Sanskrit.

Much more might be added on this important topic, but I forbear. I have already made my address too long, and many able writers are publishing their investigations in comparative philology, and clearer light is being thrown on the subject than has hitherto been obtained. It is apparent that various and long-continued migrations of the people, and the consequent admixture of the races, are the causes to which we may attribute the dismemberment and corruption of languages.

History affords us some evidences of the stupendous upheavals of Asiatic peoples, and the changes and convulsions which overthrew one nation after the other when Assyrian, Babylonian, Persian, Greek, Arab, Saracen, and Tartar successively struggled for supremacy, and displaced and superseded each other in power; and in their march of conquest overran India, extending further and further eastward. From these causes we may look for a continued intermixture of races; and the turbulence of war propelled weak races to seek asylums at a distance from their conquerors, and such asylums may have been found in the Pacific Islands, from the Malay Archipelago to the coast of America.

You will pardon me for a slight digression, and permit me, as an old Polynesian missionary, to add that a desirable aim in our pursuit is to awaken increased interest in the remarkable people of the Pacific Islands, and to desire above the solution of scientific questions an ethical and benevolent inquiry—How may these people be best reached by evangelical and civilising influences? Thus, our investigations will possess a tone and object of vast moment to the future well-being of the Polynesians.

Section G.

ECONOMIC SCIENCE AND AGRICULTURE.

ADDRESS BY THE PRESIDENT,

H. C. L. ANDERSON, M.A.

(Late Director of Agriculture, N.S.W.).

Permit me, in the first place, to express my deep regret that I have been prevented from being present to preside over the meetings of the section—an honor to which I had been looking forward with all the bright anticipations which we have learned to associate with Adelaide in its lovely spring time.

The fact of taking charge of a new department of our Public Service but three weeks before the Association meeting has robbed me of my expected pleasure, but it has not prevented me from doing myself the honor of placing before this section a few thoughts on a subject of the deepest interest to South Australia, in common with New South Wales and the other Australian Colonies.

As it seems peculiarly becoming that "Agriculture" should this year, when the Association meets in an agricultural colony, have been added to the title of this section, I cannot do better than confine my attention to that branch of our subject, and more especially to that aspect of it with which I am perhaps best acquainted—the state of agriculture and agricultural education in New South Wales.

Whatever may be the causes—and they are many—New South Wales is not an agricultural country to such an extent as we might fairly expect from her age, her richness of soils, her great diversity of climatic conditions, and the character of some of her founders.

We have not hitherto supplied ourselves with bread, though it is expected that this year we shall do so. We import agricultural products, all of which we could ourselves produce, to the value of more than £3,000,000 per annum, while our exports of wines, fruit, butter, and a few other articles reach barely one-tenth of that amount.

We export every year from 4,000 to 7,000 tons of bonedust and dried blood—the very bone and sinew of our pasture—to New Zealand and Mauritius, and bring them back in the form of oats, potatoes, chaff, sugar, and other produce.

We have had a system of education admirably adapted for the boys intended for city life, but which had till three years ago little agricultural flavor in it to recommend it to those who are to go on the land.

We have a very complete system of general education, leading from our public primary schools through our superior public schools, our high schools, and our grammar schools, to the university with its complete courses in arts, medicine, law, science, engineering, and philosophy; but, until two years ago, the only systematic instruction in agriculture was through the agency of the night classes at the Technical College, where Mr. Angus Mackay has done very useful pioneering work. For years this gentleman had to act as agricultural chemist, pathologist, entomologist, botanist, and general agricultural expert for the whole colony, and did much, single-handed, to arouse interest in the subject and to stimulate a spirit of inquiry.

The general body of our farmers in New South Wales are men who have had no previous experience in agriculture, but have gone on the land through pressure of circumstances. Their own brave hearts and strong arms have enabled them, with a rich virgin soil, to achieve good results while prices were high and as long as the soil retained its fertility and pests and diseases caused little trouble.

Things have been generally prosperous till a few years ago, when problems began to present themselves which the merely practical man could not solve after any amount of theorising and vain imaginings. The wheat farmers became concerned about the periodic visitations of rust, and though some of the more advanced thinkers were quite certain that it was only "a hinsect," this happy inspiration did not bring with it any suggestions as to remedial or preventive measures. *Phylloxera* seriously menaced our vine-growing industry, and we suddenly found that, with all our accumulated wisdom, we knew nothing about this little insect's life history, and our ignorance led us to work out our own salvation in a very clumsy and expensive manner.

Our orchardists began to find the codlin moth a serious trouble, and though this beautiful little moth had been with us for fifty-three years, it had been nobody's business to cultivate friendly relations with her, nor to prosecute her with arsenical sprays and crafty bandage traps, so that many of our oldest orchards became useless to their owners and breeding grounds to infest the whole colony.

Aspidiotus aurantii was playing havoc with our old orange orchards; *Schizoneura lanigera* and *Mytilaspis pomorum* were reducing our apple-growers to despair; and yet the man who blamed protection for it all was as successful in stopping the ravages of these insects as the man who thought that untaxed bananas from Fiji were ruining the fruit industry. Simply because the one was as ignorant of the true cause of the mischief as the other, and it was casier to blame politics than to deal with the scales.

Many of our orchardists, after treating their orange trees with bonedust for ten or twenty years in succession, found this phosphatic manure beginning to lose its efficacy; but they could not agree as to the cause, some blaming the manufacturers, others the sheep and cattle which were not building up their bones with the same phosphate of lime and gelatine as in the good old days. If, perchance, some enthusiastic experimenter hinted that perhaps the soil and the tree needed some potash to make its diet more complete he was laughed at as a harmless lunatic, and invited to offer his kainit and other foreign stuff to those who knew no better.

Our dairy farmers were finding their pastures deteriorate, and though they were vaguely conscious that our indigenous grasses—*Eragrostis leptostachya*, *Danthonia pallida*, *Cynodon dactylon*, *Andropogon sericeus*, *Astrebula triticoides*, *Chloris truncata*, *Pappophorum nigricans*, and a hundred others—stood by them well in their drougthy seasons, they all with one accord sowed the *Loliums*, *Poas*, *Fescues*, and other tender European grasses, alike on the dry hill sides, the hot western plains, the sub-tropical river banks, and the New England tablelands, because perhaps our dairy farmers in the south coast district, with its mild climate, regular rainfall, and rich deep soils, had found these grasses do well in any average season.

In short, so many troublesome problems were presenting themselves to our farmers, graziers, orchardists, and vigneronns with reference to their soils, their crops, their stock, their insect pests and fungus diseases, and many other matters of vital importance, that the more intelligent of our agriculturists, recognising that they could expect no light from their neighbors—no more enlightened than themselves—asked for the formation of a Department of Agriculture. Each of the other Australian Colonies had such an educational agency, in one form or another. Victoria had two agricultural colleges in full working order, South Australia had her Roseworthy, but the mother-colony had done almost nothing for the agricultural community.

In February, 1890, the Hon. Sydney Smith, M.P., was appointed the first Minister of Agriculture, and at once entered with vigor upon the work of forming a department adapted to the needs of the men whose interests it had to serve. The objects were stated as follows:—

To obtain data necessary to complete the history of agriculture in New South Wales.

To collect, arrange, publish, and disseminate for the benefit of the agriculturists of the colony all useful information in regard to agriculture in its many branches.

To recommend, by gathering together the highest agricultural experience of other lands, the best methods of culture, the choicest grasses, cereals, plants, vegetables, fruit, and other

- suitable crops, the most improved implements of husbandry, and all other improvements of interest to the farming community.
- To introduce and distribute new seeds, cereals, plants, and cuttings from other lands with climatic conditions similar to our own.
 - To answer questions submitted by those striving after better methods and more advanced ideas in agriculture; to stimulate inquiry, and to invite discussion from agriculturists of all classes; to test, by experiments in different parts of the colony, seeds, trees, implements, improved methods, new crops, manures, and everything else of local interest to the farmers of the surrounding district; to analyse typical soils of the colony, commercial manures, indigenous fruits, ashes of plants of all kinds, Australian wines, medicinal products of the native vegetation, as well as testing supposed poisonous plants to discover the nature of their injurious qualities; to record and describe the botany of the colony.
 - To investigate the insect life of economic interest to our farmers and fruitgrowers, distinguishing between friends and foes; and convey the information thus gained in the clearest possible way for the information of those directly interested.
 - To form a museum, which will contain specimens of all products of economic importance grown in the colony; collections of insects; named fruit models; typical soils, with their analyses; samples of manures available for farmers' use; models of implements and machines; and any other objects that will be of educational value to the farming classes.
 - To get together an agricultural library which will contain the wisdom of all countries upon the different subjects connected with agriculture, from which appropriate advice can be always obtained to supplement the practical experience of the experts of the department.
 - To educate adult farmers by means of lectures, practical demonstrations, and by experimental farms, and to stimulate them to healthy rivalry by means of national prizes; to educate the youth of the colony in the best science and practice of agriculture and its many allied subjects, by means of a system of education graduated from the primary schools up to the university, and having for its sole object the study of both the practice and science of agriculture.
 - To disseminate useful knowledge gained at home and from abroad, and thus cause a rational system of agriculture to be established in New South Wales.
 - To indicate improved methods by which to learn how to turn the land to better account, and to get the greatest possible return from any given area, and to grow the most suitable crops at a minimum of cost and maximum profit.

To make the farmers' condition more stable, and thus raise the status of the settlers, who will found a generation of farmers, instead of squatters' dummies, to make agriculture the mainstay of the country.

To assist in extending our markets for the disposal of the surplus of such crops as fruit, maize, wine, &c. ; to enlarge our productive capacity, so as to completely supply our own wants in such crops.

Above all, to bring the agriculturists of the colony into such close and cordial relations with the department as will make them acquainted with its work, and inspire them with confidence in its ability to serve them, and at the same time make the officers of the department informed of the difficulties and needs of the tillers of the soil.

In choosing a scientific staff for the new department, the Minister was very fortunate in securing the services of the most able men—each in his own line of work—available in New South Wales, and their record of original investigations has amply justified his choice.

Dr. N. A. Cobb has done work of the utmost value to the other colonies as well as to New South Wales. He has investigated and identified the principal fungi attacking our farm crops, fruit trees, and vines, has figured and described their diseases, indicating either the approved remedies or those likely to prove effective under our conditions. He has fully investigated the different rusts that affect our cereals, more especially the *Puccinia graminis* and *P. rubigo-vera*. His series of articles on these rusts, illustrated by his own drawings, have enlightened our farmers as to the true nature of this parasite, and have convinced many of them of errors of treatment in the past. Acting on the valuable suggestions of the three intercolonial conferences on wheat rust that have met successively in Melbourne, Sydney, and Adelaide, Dr. Cobb has devoted several months to the examination of each of the 600 wheats cultivated experimentally by Mr. W. Farrer, of Queanbeyan. His methods, lines of investigation, and practical deductions were published, admirably illustrated, in the *Agricultural Gazette* of New South Wales, vol. 3 (1892). Following up this profitable line of work, he has photographed and accurately described the 375 best varieties of wheats grown in Australia, a complete stool of each of which has been sent to each of the other colonies for reference purposes. These sorts are being further tried by Mr. Farrer, working with Dr. Cobb, and by the latter on an experimental plot of ten acres at Wagga Wagga, as well as by over 500 of our farmers, to whom small packets of the best sixty-five varieties have been issued. It may be confidently expected that the result will be much additional light on the exact conditions that favor the spread of rust ; the inherent properties of the plant that enable certain varieties to resist rust better than others ; and the methods to be adopted to raise, by cross-fertilisation, varieties of

wheat at once suited to our climatic conditions, resistant of rust, and not too distasteful to the fastidious tastes of our millers, who have to cater for the public in their demand for a white flour, regardless of its flesh-forming or bone-making properties.

Dr. Cobb has also investigated the mysterious "takeall" in wheat, which has long exercised the minds of our farmers. His exhaustive article on the subject in the *Agricultural Gazette*, vol. 3. part 12 (December, 1892), has clearly indicated the principal causes of the disease as known to us in New South Wales.

During the present year Dr. Cobb has given special attention to the mysterious disease that was attacking the sugar-cane on our northern rivers, and the results of his microscopic investigations in the cane fields and the laboratories of the Colonial Sugar Refining Company enable him to suggest remedial measures for this disease, and explain to us the unsuspected cause of allied diseases in our fruit trees and other crops. Though he discovered no less than six different fungi and twenty species of nematodes, none of these could account for the mischief reported, which turns out to be associated with the presence of a microbe in the sap of the vessels of the cane indicated to the eye by the exudations on freshly cut surface of a yellow gummy substance. Dr. Cobb's exhaustive report, now in press, shows that this disease, which he calls "gumming of the sugar-cane," never occurs without the presence of this gummy matter, which never occurs without the microbes, and is, in fact, a product of their growth. He proposes to inoculate healthy cane with this microbe, *Bacterium vasculorum*, and the results will, in due time, be recorded. Another valuable line of work now in Dr. Cobb's hands is the question of worms in sheep. He has erected a laboratory at Moss Vale, and is systematically examining the grasses and other fodder plants of this infected district for their microscopic fauna, and comparing the same with the larval stages of the worms parasitic in sheep—an entirely new line of inquiry, which will result in filling up some gaps in the life history of some of these worms. When the complete life history of these worms is known preventive or remedial measures will suggest themselves, as was the case with trichina and hydatids. He has already discovered larval forms in the sheep's dung, and we may therefore look forward to the publication in due course of results of practical value.

During the past year the Chemist of the department, Mr. F. B. Guthrie, has done valuable educational work. He has analysed very completely eighty typical soils from different parts of the colony, and has made a systematic examination of all the manures offered for sale in New South Wales. From these analyses we have been enabled to value on a common basis all our commercial fertilisers, and the results as published in the *Gazette* have indicated to those interested how they can most cheaply and effectively manure their crops and improve their soils. The result has been

to stimulate immensely the manure trade in New South Wales; one company alone selling, in 1892, 3,000 tons of high-class manures where they sold only 300 tons in 1890. Mr. Guthrie has also devoted much attention to the analysis of several supposed poisonous plants, notably the Darling pea (*Swainsona galegifolia*), and has encouraging indications of being on the track of the cause of the trouble to sheep from this peculiar plant. The chemist's experiments with the Babcock milk-tester, and his analysis of ensilage, milks, artesian waters, wheats, fruits, wines, and ashes have been of great service to different classes of our farmers.

He is now engaged in determining the composition of the "gummy" substance—which is not, however, a gum—that Dr. Cobb has been investigating and has called *vasculin*.

The Botanist has done much since the creation of the department to educate our farmers and their children on the economic value of our indigenous grasses and other forage plants. He has published a census of the grasses, giving a full description of the principal 195 grasses of New South Wales, with twenty-four exotics that have been naturalised. Excellent drawings of sixty of these have been reproduced by photography, and have been of great service to many persons studying this most useful order of plants. Examples of these drawings are submitted herewith, as indicating a valuable means of educating our students by means of wall pictures and plates in text books. Mr. Turner has also published a volume of the forage plants of Australia, giving exact information with excellent drawings of ninety of the saltbushes and other fodder plants that have been so useful to our pastoral industry. He has also published a series of illustrated articles dealing with supposed poisonous plants, numerous weeds, and new economic crops that might be profitably introduced into Australia.

The work of the entomologist (Mr. A. S. Olliff) has been of special value to the orchardists, who as a class needed special instruction on insect pests and the best means of combating them. He has made good collections of scale insects (*Coccidæ*) destructive to fruit trees, and one of gall insects (*Hymenopterous*, *Dipterous*, and *Homopterous*) affecting fruit and timber trees. With the aid of a collector, over 18,000 insects, including a large number of parasitic and predaceous enemies of the injurious insects themselves, have been got together and suitably mounted and displayed for the instruction of those concerned. Small cases of the most important insects—with complete life histories—have been sent round to the agricultural shows of the colony, and have aroused great interest in thousands of fruit growers, who are now taking vigorous measures for the destruction of their insect enemies and the conservation of their friendly lady-birds (*Orcus chalybeus*, *Orcus Australasie*, *Halyzia galbula*, *Leis conformis*, *Verania frenata*, *Vedalia cardinalis*, and others) which do such serviceable work on the different scales and aphides that infest our fruit trees.

The original investigations of Mr. Olliff on the saltbush scale (*Pulvinaria Maskelli*), bronzy orange bug (*Oncoscelis sulciventris*), the orange borer (*Uracanthus cryptophagus*), the pumpkin beetle (*Aulacophora hilaris*), the potato beetle (*Monolepta rosea*), and the potato moth (*Lita solanella*) destroying tobacco, are worthy of special notice.

Experiments are being conducted with the parasitic fungus (*Botrytis fenella*) that has been found so destructive to cockchafer larvæ in France. The results hitherto in our cane and maize fields have not borne out the favorable reports from the French vineyards.

I submit for your inspection a number of illustrations of insects, grasses, fungus diseases, and new commercial crops, from the pen and brush of Mr. E. M. Grosse, the artist of the department. I think you will agree with me that these are quite up to the standard of such works in older countries, and are better adapted to adorn the walls of our schools and colleges, and to illustrate our reading books and Australian agricultural text books, than the useless reproductions we so often see.

The whole of the original investigations of these specialists, admirably illustrated by the artist, have been published from month to month in the official publication of the department—the *Agricultural Gazette* of New South Wales, of which 5,000 copies are distributed free to *bonâ fide* agriculturists and fellow workers in these subjects in other countries. I cannot speak too highly of the good influence of this publication in educating our most intelligent farmers, in stimulating the younger men to study, in bringing the department into constant touch with the more progressive students, and in communicating our work to other countries, and thus earning generous exchange of reports, bulletins, and current literature.

The vignerons of the colony have been much assisted by the services of Mr. J. A. Despeissis, viticultural expert, who has visited all the vine-growing districts to give practical instruction, and has written a series of articles on "The Vineyard and the Cellar," which, when completed, will form a valuable text book on vine-growing and wine making.

A thoroughly practical fruit expert (Mr. A. H. Benson) has visited all the fruit growing centres, giving instructions in all the operations of the orchard, and doing special good by practical demonstration of the mixing of the best fungicides and insecticides, and their application by means of the excellent spray pumps now available from America. Under his supervision valuable experiments have been carried out to discover the conditions under which fruit can be best kept in cold storage, with a view to opening up larger markets and making more stable conditions for our fruit industry.

A travelling dairy was sent round all the districts likely to take up this branch of agriculture, and a large number of pupils have

been instructed by Mr. M'Caffrey in the most modern methods of butter and cheese making. Factories have been started in new districts, and increased prosperity secured to them through this profitable industry. Mr. M'Caffrey has also written, in conjunction with Mr. J. P. Dowling, a handbook on dairying in New South Wales, which will, I believe, supply a distinct want.

Farmers have been encouraged to experiment with new varieties of seed and new economic crops by the issue of 13,235 packets of seeds, plants, and cuttings to 3,182 applicants.

I have endeavored to describe briefly the principal steps that have been taken by the Department of Agriculture in New South Wales to educate those now on the soil.

Every man who has travelled throughout the agricultural districts of New South Wales, and has noted with intelligent eyes the progress of agriculture, both as an art and a science, must have satisfied himself that there has been a steady, though perhaps slow, progress in most of its branches during the past few years. He notes improved agricultural implements being largely used, better homes, brighter gardens, more extensive vegetable plots, more convenient barns, better fences, more drainage, more skilful use of the subsidiary aids on the farm, more economical conservation and application of water, and more co-operation in matters of mutual interest; more markets have been opened up, and better access to those markets has been provided. In short, since by beneficial legislation men were encouraged to select portions of land suitable for agriculture, and entered upon its possession as *bona fide* settlers, their positions have generally improved in every material direction, till they have in many cases become independent freeholders, enjoying most of the comforts and simple luxuries of the old civilised countries, forming the sinews of this young country, and supplying its greatest source of strength in peace and war—an internal food supply. But while recognising with thankfulness these signs of improvement, it may not be out of place to inquire what are the conditions essential to a still grander progress and prosperity.

These, I think, might be defined almost on the same lines as those laid down by Mr. Isaac Newton in his first report as Commissioner of Agriculture for the United States of America:—

- (1) Good government, which will continue to provide wise land laws, and favor in every way possible those who form the great source of wealth to this as to every other country.
- (2) To increase the demand for agricultural produce at home and abroad, and to utilise in more ways our home products.
- (3) To increase the respect paid to honest labor.
- (4) To improve the condition of reproductive labor.
- (5) To impart a better knowledge of the science and practice of agriculture by providing farmers, and more especially their children, with a better education in all the branches of agriculture and its allied subjects.

I shall content myself by offering a few thoughts on the last proposition.

I think that I have shown that in New South Wales a great deal has been done to educate our adult farmers, and to help those who wish to help themselves, but I cannot help feeling that in this we have commenced at the wrong end. It is to the rising generation that we must look for profitable results from our labors, and in their interests I should like to see a complete system of agricultural education adopted throughout the whole of Australia.

Feeling as I do that, in order to make Australia an agricultural country in the highest sense, we must give our children the best technical training possible, I must assume that the State will undertake this line of education as it has done, whether for good or for ill, with all the other branches of education—literary, professional, and technical. After twenty-two years' practical acquaintance with all the systems of education pursued in New South Wales, I hope that it will not be considered out of place for me to discuss the means by which our national schemes of education can be made to have a stronger agricultural flavor than at present, and can be further supplemented by the State so as to meet a distinct want for agricultural education—graduated to suit alike the free selector's son and our future professors of agriculture.

But before I discuss the means by which our boys can be trained in the practical operations of the farm, orchard, dairy, vineyard, &c., as well as in the sciences which have so much bearing upon these operations, I would venture to express the opinion that the principal part of the child's education has been commenced before he or she has come under the control of the public teachers. I cannot help feeling strongly that our best farmers are those that have conceived in their early infancy a liking for country life, a taste for outdoor work, and a strong desire to add to the material wealth of their country. I very much fear that young people who have been brought up in dwellings which are deficient in all the best attributes of a home, where everything is squalid and ugly, and no attempt is made to beautify in a simple way the home and its surroundings, such children can hardly have such a love for a country life or for the manual toil which is inseparable from an agricultural occupation as will induce them to stay in the country with its early disadvantages, instead of congregating together into the towns and cities which have such attractions for the young and thoughtless.

In the first place, then, we must teach our boys and girls to respect honest labor, to consider that manual labor is as honorable as that which is followed in city offices, shops, or warehouses.

All unselfish parents will make the home as attractive as possible to the boys and girls, and provide them with such simple amusements and pleasures as their circumstances will permit; will make the surroundings of the farm house congenial by means of its garden, its vegetable plots, its orchard and its playground; will

allow the young folk a fair leisure for their own pursuits; will encourage their children to study books that refer to their special calling; and will direct their attention to the praiseworthy examples of men who have raised themselves to the most honorable positions in the State, and have advanced the best interests of their country by their success in agricultural pursuits.

There are doubtless many disadvantages inseparable from a country life, more especially in newly-settled districts and during the early struggles; but these should be minimised as much as possible, while the advantages of the freedom, the healthiness, and independence of farm life, with its delights of overcoming difficulties, its ever-changing pleasures and its noble influence on their country's destiny, should be kept constantly before the minds of our boys and girls when at their most impressionable age, instead of holding up to their envy the circumstances of those in city occupations whose genteel clothes, clean hands, and generally more luxurious mode of living, place them in the opinion of some silly parents on a higher plane of "respectability" than their rough-spun cousins in the country.

When our country boys and girls start out from home to go to the nearest school they should do so with the feeling that their father's occupation is as honorable as any other, and has its own peculiar attractions, pleasures, and good prospects. They should not start their school life with the idea that the ultimate object of their education is to learn a little Latin, a little algebra, a little Euclid, a little French, and a little of many other subjects which will have but slight influence on their after life. They should start with the definite idea that they are going to be agriculturists in one branch or another, and that they must give their special attention to the different branches of study that will fit them for their future calling. As one who has gone through the full classical course of our own university, I may be permitted to indorse most strongly the continental views rapidly gaining ground amongst Englishmen, that education as such can be given quite as effectively through the medium of sciences, including those bearing upon agriculture, as through the exclusive medium of dead languages and pure mathematics. I would also express my belief in teaching facts before abstract principles, and in educating by means of objects rather than by means of symbols. The instructions to teachers in French elementary schools say:—"They should commence by employing visible and tangible objects, which they should make the children see and feel . . . then by degrees they can exercise them by obtaining from these objects abstract ideas, by comparison and generalisation, and by use of the reasoning faculties."

In other countries of the world at the present time great attention is being paid to agricultural education in the primary schools. The reading books have judicious selections appealing to the

patriotism of their readers, holding up to their admiration a love of country life, and giving instructions in the different operations of an agricultural occupation. It is beginning to be felt even in England that the country boy, instead of learning mythology, history of the fabulous class, sentimental poetry, stories of travel, and other subjects of little personal interest to himself, should be taught the "why" and "wherefore" of all the stages of growth of the different plants; the composition of the soil and mode of its formation; the history, uses, and methods of cultivation of the principal plants of his own country; and the chemistry of the water, soil, and air, which would be his chief assistants in his future calling. He should be instructed in the elements and seasons; the weeds of the farm; the animals and poultry; the vermin and insects; the implements and tools; the machinery of the farm—all being used in conjunction with other subjects of general instruction that form the basis of a practical education.

It is felt that the walls of schools in agricultural districts, instead of being adorned with pictures of wild and strange animals, maps of distant and foreign countries, and pictures of manufactures belonging to towns, should have now-a-days illustrations showing insects injurious to farm crops and those which are parasitic or predaceous on them; illustrations of the different cereals, showing their periods of growth from the seed to the full ear; pictures of types of all kinds of domestic animals, farm implements, local grasses and weeds. Plants of all kinds that can be grown in the respective districts are always before the children's eyes, so that the schools in the farming districts have an agricultural flavor about all their teachings. The masters encourage everything connected with agricultural pursuits, and the children's ambition is to excel in the special branches of agricultural knowledge, and they consequently know more about manures, the points of a horse, or the construction of a plough than about Latin roots or Euclid's problems. Some of the school boards in England have published a few excellent wall cards illustrating the life history of a few of the insect enemies of farm crops; also the different stages of growth of a wheat plant from germination to fruition.

It is felt that the object lessons which are of value as a means of instruction in the primary schools should be made as appropriate as possible for the class of scholars being taught. It would surely be better to give object lessons on the animals reared in the district, and on crops peculiar to it, showing from the objects themselves the lessons to be learned in relation to their uses and mode of growth, rather than to give lessons on a whale, a swordfish, a rhinoceros, a crocodile, a unicorn, an elephant, or a camelopard, as is often done.

In New South Wales the value of agricultural education has been recognised by the gentlemen at the head of the Department of Public Instruction, and the result was the issuing of an admirable

circular in April, 1890, by order of the Hon. J. H. Carruthers, M.P., then Minister for that department, from which the following extracts are taken :—

“The Minister for Public Instruction is anxious that the lessons given in the public schools should be of as practical a character as possible. He has therefore decided that in future teachers be invited to give special attention to agriculture and horticulture.

“Instructions in these subjects can best be given in the form of object lessons, and you will find that it is so provided for in the revised standards of proficiency.

“The lessons might take up the work in three stages, thus —

“First stage—The principles influencing the supply of plant food in the soil, the necessity for cultivation, and the circumstances making tillage more or less effective.

“Second stage—The principles regulating the more or less perfect supply of plant food; manures, as supplemental sources of plant food.

“Third stage—The principles regulating the growth of crops, and the variations in their yield and quantity.

“With a view of encouraging teachers in giving practical illustrations indicated, the Minister has decided to give annually a bonus to each teacher who has results to show. The bonus will vary from £1 to £5, according to the quantity and quality of the work done.”

There are at the present time in our public schools many teachers who take a keen interest in agricultural matters, and are well able to teach theoretically, and in some cases practically also, the principles of agriculture. During the year 1891 the bonus referred to was earned by eighty-eight teachers, but I hope yet to see a much greater number of the country teachers undertaking the practical education of their pupils in the working of small gardens and experimental plots in connection with their schools. This plan has been found most effective in France, and did immense good at the critical period of the agricultural history of Ireland, imbuing the children with a love of nature, and different operations of tilling the ground, and teaching them to think of the reasons that prompt those operations on the farm.

The important subject of tree-planting has also been recognised by the institution of Arbor Day in our schools, and the reasons for it are thus set forth in a circular by Mr. E. Johnson, the Under-Secretary :—“The improving of school grounds by tree-planting is recognised as a work of educational importance. By such means the school will be made attractive, and an interest in nature and a love for the beautiful will be stimulated and encouraged among the pupils. In time, also, the summer shade, so necessary in our climate, will be provided for the children, and thus the general comfort and happiness of their school life will be promoted. Much useful knowledge respecting the nature and growth of plants will, moreover, be obtained by the pupils; and, from working to improve their school

grounds, they will be led to plant and beautify the grounds about their homes. In this way the information and advantages gained will be likely to have a permanent effect." Succeeding generations of school children will have reason to bless the Minister who instituted Arbor Day in New South Wales.

I believe that the liberal and progressive gentlemen who guide the destinies of our Department of Public Instruction will, in the course of time, make the teaching in our agricultural districts as practical and valuable for the children concerned as the general teaching is for our city schools. In due course the schools in farming districts will have special reading books dealing with the many interesting subjects connected with agriculture, specially written and illustrated to suit the conditions of Australian farming. They will have maps, pictures, and illustrations representing the plants, insects, and domestic animals of the respective districts. They will have object lessons given by intelligent and enthusiastic teachers, all having a distinct agricultural bias, and in a limited number of cases little gardens and plots worked by the children themselves under the teachers' supervision.

And here, when we begin to talk of teaching practical agriculture to our rising generation, it may seem proper to inquire what agriculture is, whether a science, an art, or a business—each and all of which it is called in these days.

If it were merely a science it could be taught at school or college as is done in Germany, with a small experimental farm as a laboratory, in the same way as chemistry is taught. I am strongly of the opinion that agriculture, as suited to the conditions of this country, can never be taught in such a way. Though agriculture may not be strictly defined as a science, I should rather be inclined to call it the application of several sciences to one particular purpose—the cultivation of the soil.

It is an art, inasmuch as it needs a workshop, that is, a farm, for the exercise of the pupils; and it is a business, as it needs a regular system of apprenticeship to learn the many operations of commercial life necessary on a well-managed farm.

Mr. J. C. Morton, in a lecture before the Royal Agricultural Society of England, made the following pertinent remarks:—"Agriculture is an art or manufacture. It is also a business or trade; and people have of late years got into the habit of calling it a science. By this last designation it can, of course, be meant only that the facts which make up the experience of the farmer—like those, indeed, of any experience whatsoever—are recognised by many scientists as in perfect keeping with the laws of nature. Agriculture, though not a science, has thus at length become a museum, as it were, of facts and instances and specimens, in the classification of which students of all sciences have been successfully at work, so that every part has now the right upon it of a well-defined relationship with scientific truth. If this be a correct

account of agriculture as so-called science, how is it with agriculture as a trade? There is here an even more complete explosion of the idea of anything exceptional and mysterious. The relationship of the farmer to him of whom he hires the land which is the manufactory, to those of whom he purchases the labor which he directs, to those who are his customers, to those of whom he is the customer, is of the ordinary kind, dependent for its establishment and maintenance on the ordinary principles of human nature, and requiring only such protection from without as an equitable administration of the law secures for it. But agriculture is especially a manufacture and an art dependent on professional intelligence and skill; and here, of course, we come upon the essential features which distinguish it. I believe that I am right in saying that its chief and ruling characteristics have arisen from the fact that throughout it deals with life. To be a good and successful agriculturist therefore needs not only familiarity with the ordinary routine of farm practice, and both industry and promptitude in its direction; it needs especially:—(1) The qualities of patience, by which a full share of the farm work is given to nature to accomplish; and it needs especially, (2) The exercise of quick-sighted observation, by which the earliest natural indications of what is going on, the earliest intimations of natural tendency of movement, whether to the good or bad, are detected in the living creature with which the farmer has to deal. Intelligence, activity, and promptitude in carrying out the routine of operations are necessary to every other business as well as that of farming, but none other, unless it too have equally to deal with life, so needs the exercise of quick-sighted, careful, habitual observations for its successful prosecution. A quick and watchful eye, and prompt activity at the right moment, have to be united with the faculty of waiting to the proper time in order to secure good agriculture."

In order to secure such a complete training as is here indicated we should have a national—may I venture to hope a Federal Australian—system of agricultural education, which will take boys, and, if necessary, the girls after they have left the primary schools, and give them a thoroughly practical and scientific education in the different branches of agriculture for which they are intended. For this purpose we shall need farm schools in different parts of the colony, and these, I hope, will be started on the model of similar institutions in France, where practice and theory are taught together, and not as in Germany, where the theory is taught first and the practice is acquired in after years, if ever. At these schools boys of 14 years of age would be admitted, the only necessary qualifications for admission being a fair English education, good health, and a good record from a previous school. It is admitted that the system of agriculture in France is as good as any in the world, and that the great source of wealth of that country is her agriculture as practised by the French peasants.

Some years ago, when the butter industry in the south of Ireland had fallen off to a great extent and was threatened with extinction, the Education Board of that country started the Munster Dairy School, at which special instruction was given during two sessions per annum to the daughters of the surrounding farmers. Several hundred young girls at once went through this course of instruction, and the result was soon seen in the immense improvement in the quality of the butter made and in the restoration of the Cork butter trade, while the improvement in the value of Munster farms is computed at an immense sum.

In the same way it would probably be found in Australia that special schools for the study of dairying, viticulture, fruit-growing, and other minor industries would be of immense service in bringing those branches of agriculture up to the position which they must eventually hold in this country.

At the majority of the farm schools so established general agriculture would doubtless be taught, or, in other words, the mixed farming which would be most suitable to the surrounding district. Boys would get a knowledge of stock, of all the principal operations of the farm, rotation of crops, draining, use of artificial manures, farm implements, the blacksmithing and carpentry needed on the farm, the use of an engine and other necessary machinery, and many other things which they might not be able to learn on their fathers' farms.

I imagine that I can hear the criticism that farmers' sons could learn all these things at home as well as at a farm school. Perhaps so, if our best farmers could find the leisure and opportunity to personally instruct their sons in all the operations of the farm, and at the same time teach them the "why" and "wherefore" of each of these operations. But we know that the old saying about "the shoemaker's children being often worst shod" holds good also with education. Children of the best educated parents do not always get the best education from them.

But even granting that our best farmers may find the time and opportunity to instruct their sons methodically and practically in the science of their calling, must we not make provision for those boys in the towns and cities who wish to leave such a life and learn farming as a calling, as well as for the sons of farmers who have not themselves had the advantage of a good farm training and hope to give their sons better advantages than they themselves have ever had. It is a recognised fact that farmers' sons, as a rule, begin their business in life with a general education inferior to that of men in other walks of life corresponding in the social scale with their own. They are removed from school earlier than those destined for mercantile pursuits, or even those intended for clerical work, and hence a young farmer often begins his business with a small liberal education and with none at all of a technical character concerning his future work. He is, therefore, but little

more enlightened than his father with regard to modern improvements in artificial manures, drainage, management of stock, new implements, and better methods of cultivation.

I am aware that a grave objection to this scheme of education in the minds of many of our small farmers would be the expense, not only in the actual outlay for fees (which would probably be made very small), but also in the loss of the boy's services at a time when he is becoming useful on the parental farm.

As one who is proud to acknowledge his indebtedness for his education, and the consequent pleasure of doing, or trying to do, some useful work for his fellows, to the unselfish love of parents who preferred their children's interests to their own personal comfort and luxury, I would venture to assert that nothing our farmers can do for their children will be more likely to bear such a rich harvest of filial gratitude and unmixed satisfaction in after years as the memory of the sacrifices they made for their children's sake in the pioneering days when they were struggling with a new farm and a young family. Every true parent who wishes to see his children rise to a higher plane of usefulness in the commonwealth, and attain to greater success than he himself has been able to do, will think little of the strict economy and personal privations that will be necessary to enable him to give his children the best education the State can afford, and to allow them the fullest opportunities of improving their knowledge of their profession, and thus becoming as valuable citizens as possible to the country at large.

Doubtless the system of bursaries which prevails at our university and at our high schools will be extended to this class of school also, and thus settlers and struggling farmers who cannot pay the necessary fees, however small, as well as lose their son's valuable services just as he is becoming of use to them, will be able to see their boy educated at the cost of the State by the aid of a scholarship earned by his own honorable industry and perseverance.

When a lad has spent two years at such a farm school he should have such a knowledge of stock, farm implements, and general farming operations as to be fit either to return to his father's home as a useful assistant, or to go on to a higher school of agriculture, where the scientific subjects allied to agriculture will receive fuller attention.

To show how much these schools are valued on the Continent, I may mention that in Prussia alone there are thirty-two of them, and the same number in France, together with a large number of apprentice farms, on which the owners of first-class farms are allowed to take students to learn the principles of their calling, a bonus for each student being paid by the Government.

In these countries the system of agricultural education has developed on no fixed plan, and does not therefore present an harmonious whole. Each part of the system has been forced upon the State by the exigencies of the times, and there is therefore

no scheme of agricultural education in any of the countries of the Old World that we can copy in its entirety. There is no graduation from the schools to the colleges, and from the colleges to the university classes. There is no supervision exercised over the different grades of education to harmonise their teachings, and to bring them into correspondence with one another.

In this young country we have still an opportunity of making our system of agricultural education correspond with our national scheme of general instruction, having the university as its culminating point. I would therefore propose to offer special inducements for students from our farm schools to go on to our college, which is at present our Agricultural University. I should like to see scholarships given from each of the farm schools, to enable the holders to proceed to the college for a further period of two years.

At the college, which has now been started two years, we have two classes of students—seniors and juniors, one of which is at work each day on the farm, the other being engaged in the classroom or the laboratory. On the farm every practical operation—from fencing, cutting drains, working at the saw bench, making gates, erection of farm buildings, blacksmithing, harness-mending, pruning vines and fruit trees, budding, grafting, making a stack of ensilage, butter-making and cheese-making; each of these operations is done by the students in turn, so that each may be supposed, at the end of his course, to have had the same manual training as he would have had on the best-managed general farm.

In the class-room he goes through an advanced course of botany, with special reference to all plants of economic value; of entomology, by which to learn enough about insect life to enable him to distinguish between friends or foes, and in after life to devise means himself for dealing with the numerous insect pests with which his crops may be afflicted. He will learn sufficient geology to enable him to understand the composition of rocks—how they have been formed, and how they in turn form soils.

From his chemistry he will learn the composition of the soils he has to deal with, of the manures he has to employ, and of the crops he may grow; he will learn how to adapt one to the other, and supply the deficiencies in the soil in the most effective manner and at the least possible cost; he will learn to discern what changes take place through fermentation, and how this great agency can be controlled and utilised; he will learn sufficient veterinary science and practice to enable him to deal with the diseases of his own stock, and be a valuable help to his neighbors; he will learn a system of book-keeping that can be adapted to a farmer's requirements—a branch of education as much needed by the farmer as by any other man of business, and yet strangely neglected by them as a class. He will learn the scientific principles underlying every agricultural operation, and will be taught the reason for every such operation, however small, which he is daily performing on

the farm. All the teaching of such a college will have but one purpose in view—everything about the place, from the student's leggings and moleskin trousers up to the science lectures and demonstrations, will have an agricultural tone and bias.

In Germany the High School of Agriculture, corresponding with our college, is of a purely theoretical character, and the professors themselves admit that residence in a city like Berlin, and teaching theory alone, tend rather to give the students a distaste for the country life which they are afterwards supposed to follow, and the result is that but a small percentage of the students on leaving this high school go to actual farm work. In France, on the other hand, their National Agricultural Institute provides for practical work as well as theoretical teaching. To show how thoroughly equipped this college is, and how it is valued by the French people, I may mention that the annual cost to the State of this one institution alone is over £10,000, a sum which is never grudged, because the people are aware that from this college there are being turned out their best farmers, their most progressive landlords, and their most useful professors of agriculture.

I have heard two very different opinions expressed about the way in which the farms connected with our agricultural schools and colleges should be managed. One party asserts that the farms should pay commercially in much the same way as a private farm is made to do. The gentlemen who talk like this lose sight of the fact that a large amount to be done on the college farms must be of an educational nature. The experiments to be carried out must often be undertaken with a full knowledge that they will fail in a pecuniary sense, but will on that account be none the less valuable and instructive to the hundreds of farmers who will by their means be enabled to avoid similar costly experiments. This educational work can never be made to show a balance on the right side of the ledger in £ s. d., but who can estimate the value to the whole farming community of a series of such experiments properly conducted? On the other hand, some persons assert that the commercial aspect of the question need never be considered; that the whole object of the farm in connection with the college should be instruction of the best possible kind.

Now I cannot help feeling that no farm teaching can be properly successful unless it be taught on commercial lines, and that our students should not be taught amateur farming and experimental plot cultivation without at the same time seeing constantly before them a certain area of land farmed and managed on strictly commercial principles. I hope therefore that at each of our experimental farm schools and colleges there will be a certain area, sufficient to constitute a farm of medium size, set apart for farming operations suitable to the district, which will be carried on with a strict view to profit. The expenses of such a farm should be amply met by the returns from it, and there should be a small

surplus to pay some of the costs of working the other part, which I will call the experimental section. This, I maintain, must be worked at the expense of the State, for whether it embraces 10 or 100 acres, it cannot be expected to give yields of great value in a commercial sense. Experiments with new cereals, new fruit, new crops of any kind, would bring no money returns, for the simple reason that the resulting yields would have to be distributed free to the surrounding farmers for further experiments.

The labor entailed in cultivating small plots—for manuring, treatment of pests and diseases, and many other points of interest—is always out of proportion to the area of land cultivated, and gives practically no return in the market. I hope therefore that those who believe that our prosperity must come from the soil will be the last to object to a fair expenditure from the public purse, for the educational agencies in connection with a complete scheme of agricultural education such as I have endeavored to describe; for there seems to be no valid reason why public money should not be expended as liberally on agricultural education as has been done in the past years for our professional men at the university, and our commercial men at our grammar schools, high schools, and national schools.

I have given most of my attention to the question of educating the young, because I feel that the best return is to be expected from them; but there is also a great deal to be done in educating the adult farming population. For their benefit experimental stations are scattered over the length and breadth of the best agricultural countries of the Old World and America. In this last country alone there are fifty-eight such stations. Here a small area of ground is cultivated entirely at the expense of the State, and purely for experimental purposes. There is one of these in each State or Territory, where experiments with any new crops, manures, new methods of treatment, new implements, new varieties of fruit, methods of treating fungus diseases and insect pests, and many other similar matters are dealt with, the results are communicated to the farmers interested, and the method of working always open for their inspection and criticism. There is room for a few of these stations throughout each of our colonies, at which we shall be able to work out the many problems that are awaiting our attention. The annual expenditure on each experimental station would not be heavy, and should surely be as fair a charge on the public purse as that incurred on any of our other schools and educational institutions so liberally assisted by the State.

We have to settle the best varieties of grapes for our different districts, and the best method of treating them, in order to make distinctive Australian wines of a constant quality and recognised value; we have to determine the varieties of fruit that will best suit our different climatic regions, besides introducing new sorts not yet tried; we have to determine the most economical ways of

manuring our different classes of soils, with special reference to the crops desired; we have to find out a great deal about the treatment of fungus diseases in fruit and cereals, and of insect pests in our orchards and vineyards; we have to find out the varieties of cereals and roots best suited to the different districts, having regard to the different soils, and diseases to which certain districts are specially liable; we have to test new implements, new machines, new varieties of stock, new crops, new methods, and new ideas. This kind of work can be done only by trained men, who give their whole time and energy to such investigations, for which the State must be expected to provide the means. In France there are twenty-three such stations, and in Germany twenty-seven, where seventy trained chemists, botanists, and experimenters are employed constantly in the service of the farming community. A large amount of the work done by these scientific men has been published to the world, and has been placed as freely in our hands as in those of the men for whom it was primarily intended. It surely behoves us, as a young nation hoping to make a foremost place amongst the nations of the earth, to be up and doing, bearing our fair share in educating the great agricultural masses. We have received a noble heritage of agricultural experience and scholarship from our own ancestral country, as well as from America, France, Germany, Italy, Holland, and Denmark, and we ought surely in return to be conducting new lines of investigation on our own account, and imparting the results as freely to them as they have done to us in the past.

I have said nothing about a chair of agriculture in our university, which might be considered as a necessary coping-stone to our educational structure, because I feel that our education in agriculture is at present far too backward to need such an advanced stage for a few years to come. I assume that the university course would be one fitted to turn out specialists in all of the sciences allied to agriculture, men who would be our future principals of colleges, professors of agriculture, agricultural chemists, botanists, pathologists, and entomologists.

There is a very limited demand for such men just now. We are not yet, as a community, educated sufficiently to appreciate the value of these scientific experts. There seems to be only room for the practical farmer, and the city theorist, and clerical agriculturist who live on the farmer, not on the soil; but when we have established a number of agricultural schools of a standard equal at least to that of our existing colleges, and have raised our college standard in a corresponding ratio, we shall have room for a number of practical scientists, men who have gone through a long scientific and practical training, first in the field, then in the college classroom and experimental grounds, and finally in the university laboratories, and who will have love for, and faith in, agriculture to devote their lives to its service.

When that time has arrived I trust that we shall be so far federated that there will be needed only one chair of agriculture for all the Australian Colonies, to be established in connection with the university which may be able to offer the greatest facilities for the practical study of the sciences allied to agriculture. In the meantime, let us fervently hope that the best possible means may be devised of opening up the immense tracts of unused lands suitable for agricultural settlement, of settling genuine farmers on the soil, and of educating themselves and their children in such a way as to fit them for the highest possibilities of their future calling. If these great problems can be brought to a happy solution, federated Australia will soon be independent of the outside world for all her food supplies and economic products, and we shall be exporters instead of importers of agricultural produce to the value of millions. Men will invest their savings as readily in agricultural land as in suburban allotments, and our monetary institutions will advance money to improve farms, orchards, and vineyards on terms as favorable as they now give to the builders of city shops and warehouses.

There will be room for our boys, who now can find so few openings for their energies. We shall have towns where there are now villages, and villages where there are now the solitary roadside inns. As the population becomes denser through the holdings becoming smaller we shall have better roads, better means of communication, more opportunities of social intercourse, more attractive surroundings for the young people to reconcile them to the minor drawbacks of rural life. Our fathers have subdued the wilderness, and made farms where it was thought but a few years ago that no crops could be grown. Our sons must populate these great inland plains, and make vineyards, orchards, and wheatfields, where there are now only sheep runs, until we have a population befitting the resources of this great continent, and enjoy the advantages, pleasures, and comforts of the best agricultural districts of the old land our fathers and many young Australians are still proud to call "home."

If it be not sacrilegious to quote poetry before the members of this scientific association, I should wish that Australia may beget an intelligent and independent yeomanry like that which has done so much for the stability, prosperity, and true greatness of our fatherland, concluding with the apostrophe of Robert Burns to his native land, substituting Australia for Scotia:—

Australia! my dear, my native soil!

For whom my warmest wish to heaven is sent,
Long may thy hardy sons of rustic toil

Be blest with health, and peace, and sweet content;

And, oh! may Heaven their simple lives prevent

From luxury's contagion, weak and vile;

Then, howe'er crown and coronets be rent,

A virtuous populace may rise the while,

And stand a wall of fire around their much-loved isle.

Section H.

ENGINEERING AND ARCHITECTURE.

ADDRESS BY THE PRESIDENT,

MR. R. J. SCOTT, A.M.I.C.E.,

Of Canterbury College, Christchurch, New Zealand.

THE DIRECTION OF PROGRESS IN ENGINEERING.

When I accepted the office of president of this section, I did so believing that I should have the honor of personally opening its proceedings. Being, to my great regret, prevented from visiting Adelaide, I must be content to express the hope that the Session of this, the section of applied science, may be productive of pleasure to members attending, and of benefit to the several branches of our profession. The importance of these gatherings can hardly be over-estimated, for at them the engineer is brought into close contact with every branch of Science; and to-day, to be successful, he must be, in the true sense of the term, a scientific man, quick to grasp the practical importance and to devise means for the application of those great discoveries, to the close sequence of which we have grown so much accustomed.

The march of progress in engineering is now so rapid that, on an opportunity such as the present, it may be as well to pause in the hurry of practical work and review the ground which has been covered in the last few years, with the object of so directing our course in the immediate future that we may occupy a position in the front ranks of future advance. I propose, therefore, to-day to consider the most recent developments in those branches of engineering with which I am most familiar; and, bearing in mind that it is the commercial and not the purely scientific or interesting aspect of an invention that determines its adoption, to venture to point out the direction in which it appears to me that the light of past experience suggests future improvement.

Turning first to the cradle of all mechanical processes and engineering operations—the workshop—we find that the introduction of electrical welding has greatly facilitated the manufacture of wrought-iron piping and the various small forgings used in the gun, tool, and agricultural implement trades, whilst the fact that there is no wasting of the material by this method is in itself a

sufficient cause for its universal adoption for all descriptions of plate work. The simple fusing together now so often practised cannot, however, be regarded as satisfactory. At such a juncture the physical nature of the material must differ considerably from that of the remainder of the plate or bar, this nature having been to a great extent derived from the treatment received during manufacture. Electric welding to be efficient should, therefore, be accompanied by hammering, or by severe pressure from all directions.

A series of tests on the relative strength under alternation of stress of electrically-welded as against fused joints would probably result in much valuable information on the subject being obtained. The extent to which it is desirable to apply the process will greatly depend on the relative local cost of current and fuel, which will also be the chief factor in determining the use of electricity for heating purposes in connection with industrial operations. There is no comparison between the efficiency of direct and current heating; yet in Norway, where water power is abundant and fuel scarce, it is found profitable to utilise electricity to a considerable extent for the heating of nail rods. There a hollow carbon is brought to a high temperature by the passage of a low tension current, and the nail rod fed through it at a speed dependent on the degree of heat required. Rivets are also heated in a similar manner.

In the process of finishing surfaces there has been a marked advance. Milling is rapidly displacing planing and shaping. By milling is to be understood the shaping of metal by rotary cutters. The milling machine is capable, not alone of doing with far greater expedition all the work usually executed by the planer and kindred tools, but also of preparing curved profiles hitherto finished by filing to template. It is essentially a sizing-machine, and the work turned out from it cannot be improved by any subsequent treatment. It owes its efficiency to the use of a series of cutting edges, and a continuous feed, as opposed to a single tool-point and intermittent action. This principle is capable of very extended application, and the metal-working machine of the future will probably resemble in general character the appliances used for the preparation of timber to-day.

Few who have had charge of workshops can have failed to have noticed the inefficiency of the means usually adopted for the conveyance of power from the prime mover to the various machine tools. The wear and tear, interference with space and light, and liability to accident accompanying belt transmission are familiar to most. So keenly was this brought home to me some five years ago that I elaborated a scheme for driving each individual machine by a small "Brotherhood" engine, actuated by compressed air. The problem is now, however, solved in a more simple manner by the use of electricity; and a few years hence we shall look with

curiosity on photographs of the assemblage of shafts and strings now considered a necessary part of the equipment of a machine shop.

The advantages which the electric system possesses over its rival are numerous; not the least being the fact that an idle machine absorbs no power, there being no lengths of shafting and accompanying belting to be kept in motion, whether the whole or a single machine of the group is employed. That electric-driving has passed the stage of experiment is evident when we find that Messrs. Siemens are in their own work steadily doing away with the many independent engines they once possessed, concentrating the production of motive power, and distributing it electrically to the various shops, the machines therein being driven either individually or in groups, according to the nature of the work on which they are employed.

Messrs. Siemens inform me that a considerable economy in fuel, wages, and upkeep has already been effected, and that they propose to complete the application of this system. Messrs Easton and Anderson have for the past five years been driving electrically two overhead travelling cranes, one a 20-ton crane of 40ft. span, in which a single five-unit motor running continually effects the necessary movements through the medium of spare gearing. The current is conveyed to this crane by an angle iron supported on wood blocks and running along the shop wall. One face is ground up bright, and contact made by a sliding spring. The return is through the rails. The second crane is of 15 tons capacity, and has a separate motor for each motion, which is stopped, started, or reversed, as required, the current being collected and returned by means of overhead wires. So satisfactory has been the performance of these cranes and of other electrically-driven machines that Messrs. Easton & Anderson contemplate a complete re-arrangement of their driving plant, substituting for independent prime movers a central generating station with triple-expansion engines, from which power will be electrically distributed throughout their workshops. The Northern Railway of France find that, at a small repairing shop, substituting electric power at 6d. per B.T.U., with a separate motor to each machine, has effected an economy of 50 per cent. (all charges and depreciation included) as compared with the cost of the previous arrangement of gas-engine and belting. In mining operations hand labor is being rapidly replaced by power. Coal-cutting machines have effected a saving of about 15 per cent. of the coal vein otherwise wasted in the form of fine coal and dust. The coal is obtained in more solid and larger blocks, whilst the cost of production has been reduced by from 20 per cent. to 30 per cent. as compared with hand labor.

The transmission of power underground has been accomplished by the use of compressed air, hydraulic pressure, and wire ropes—the efficiency of such methods being from 30 per cent. to 40 per cent. By the adoption of electricity, however, the efficiency of

transmission can be raised to over 50 per cent., and, as this can be accomplished with a reduced capital expenditure, accompanied by a more portable and easily erected plant capable of supplying the power necessary for getting, hauling, pumping, and lighting, it would appear that electricity is in the future destined to become the principal transmitter for mining purposes. It is true that its use in fiery pits cannot at present be regarded as absolutely safe; but enclosed motors, non-sparking switches, and Mr. Atkinson's safety cable have greatly diminished risks which will, no doubt, eventually be completely removed.

The safety cable mentioned consists of a main and a subsidiary conductor, in circuit with each being a fuse. These conductors are connected with the same terminals at dynamo and motor, the current dividing between them in proportion to their carrying capacity. If now the main conductor be broken, the subsidiary conductor remaining intact, no spark results at the breaking, the circuit still being closed, but the whole current is thrown on the subsidiary conductor, and its fuse is melted, which occurrence, by means of a suitable mechanical arrangement, causes the whole circuit to be switched off. To carry this principle into effect the cable is composed of a closely wound spiral of tinned copper wire (several wires being arranged in parallel), which is braided over but not heavily insulated. Over this is laid a stranded conductor of the required area, and the whole is then fully insulated. If the cable be torn down by a fall, or broken in any way by tension, the inner conductor extends to an unlimited extent and maintains the circuit until, by the action of the fuse, the whole cable is disconnected.

Closely connected with mining are the tunnelling machines, which have so lightened what was perhaps the most tedious work the civil engineer could be called on to execute. The driving of the Mersey and the trial borings for the proposed channel tunnel marked a new era in such operations. An average forward progress of ten yards in twenty-four hours, with a maximum of fourteen, was obtained in the new red sandstone of the Mersey tunnel, whilst the grey chalk of the channel was pierced at a maximum rate of over a yard per hour, the heading in each case being 7ft. in diameter. In extensions of the London underground railway the needle system has proved expeditious and remarkably efficient in preventing subsidence, there having been absolutely no disturbance of the heavy buildings under the foundations of which the works have been carried.

The City and South London Railway, which, starting from the Monument, traverses the bed of the Thames, and has its other terminus at North Brixton, is carried for the whole of its length in a pair of tunnels 10ft. 6in. in diameter, lined with cast-iron segments. The heading was driven the full diameter of the tunnel by means of a cutting shield forced forward by hydraulic

jacks abutting on the completed portion of the work. As soon as the advance of the shield permitted it a new ring of segments was put in place, the cutting and lining thus proceeding almost simultaneously. The space between segments and bore was filled with grout forced in by air pressure. Where much water was met with, a stream of grout played on the working face greatly assisted the air pressure in retarding the flow. The work proceeded at an average rate of 13ft. 6in. per day.

The tendency of modern practice is thus (when the nature of the material to be pierced admits) to conduct boring operations on a large scale in a very similar manner to that in which they are effected on a small one, namely, by the removal at one operation of a core the full diameter of the finished cross section, and, where lining is necessary, to supply it in the form of large segmental pieces or even to mould it in place. In the other operations connected with railway formation the use of machinery has greatly increased the rapidity of execution. The excavation of cuttings and foundations, formation of embankments, ditching, and even track-laying and ballasting, can be much facilitated, if not entirely performed, by mechanical appliances, the adoption of which is rapidly becoming general.

The production of reliable steel of great strength and moderate price gave a great impetus to the construction of long-span bridges. That over the Firth of Forth, with its spans of 1,661ft., height above bed of Forth of 570ft., and in which 50,000 tons of steel and iron were used, will probably remain unsurpassed in dimensions until a material of still higher grade is introduced.

Turning now to inland locomotion, we find that extremely high speeds have been lately attained in England and America, and we are promised still greater velocities on specially constructed electrical railways. Such speeds as 120 miles per hour are of course possible, but would necessitate a considerable distance between the tracks, and an expenditure of energy at the rate of about 250 horsepower in overcoming air resistance alone. It must also be remembered that it would now be difficult to locate a railway of this kind in a district so populated as to afford reasonable prospect of paying traffic without its being brought into direct competition with some existing steam line having greater facilities for the exchange of vehicles, and which has probably been constructed at a far lower capital expenditure. Though the immediate future of high speed electrical railways is not promising, electricity is fast displacing other methods of traction on tramways and light railways.

In America, horse traction is being superseded by the overhead conductor, or, as it is there termed, the trolley system, on which 450 tramways, with a total of 4,000 miles of track, are now being worked. An electromotive force of 500 volts is used, and geared motors are universally adopted.

In England there are two remarkable examples of electric light railways—the City and South London Railway and the Liverpool Overhead Railway. The City and South London Railway is about three miles long, and is carried for the whole of its length in the cast-iron tunnels previously described. The average speed of the trains, including stoppages, is eleven and a half miles per hour, and their gross weight about 40 tons each. The locomotives are of 100 horsepower, and are carried on two axles, on each of which a motor acts directly. The current is collected from an insulated channel-iron conductor laid between the rails, fed at intervals from a 61-14 B.W.G. Fowler-Waring cable. The generating station is at the Stockwell terminus of the line, where there are four dynamos, each capable of supplying 450 ampères at 500 volts.

The Liverpool Overhead Railway may be classed as one of the most interesting of modern engineering achievements. It consists of six miles of double track of standard gauge running on a plate-iron viaduct alongside the Liverpool docks, and, for the greater part of its length, over the existing dock railway. There are in all fourteen stations, and the steepest gradient is 1 in 40. The main generating station (placed near the centre of the line) contains four 400 horsepower engines, each driving a dynamo capable of an output of 475 ampères at 500 volts. The conductors are inverted channel irons of steel, laid between the ordinary rails and carried on pot insulators. They are jointed by copper fishplates. The current is conveyed to the cars by means of hinged cast-iron shoes, the return being through the ordinary rails, which are electrically jointed at the fishplates. A train consists of two bogie-cars, and is capable of seating 114 passengers; each car is furnished with a single motor, the armature of which is mounted directly on one of the bogie axles. The line was first opened for traffic on March 5th last, and during the first three months 71,122 train miles were completed. Trains are now run every five minutes, which necessitates twelve trains in traffic. The average total output at the Central Station is 650 ampères, at 430 volts; the consumption of small coal is at the rate of 24lbs., costing $\frac{3}{4}$ d. per train mile. The trains stop at all thirteen stations, and complete the six miles in twenty-five minutes, the average speed, including stoppages, being 14.4 miles per hour. Not the least interesting feature of this line are the signalling arrangements, which are effected electrically, and are perfectly automatic.

The application of electric traction to existing roads will be attended with considerable difficulty. To fully equip one of the great lines on the conductor system would mean enormous expenditure, and, in the goods yards, prohibitive complication; but when it is apparent that prospective economy warrants such expenditure being incurred, there should be no insurmountable obstacle to main line and branches being so fitted.

The marshalling at goods yards could be carried on by steam or storage locomotives, and the other motors supplied with sufficient storage capacity to enable them to effect shunting operations at way stations. It is to be remembered, however, that an improved storage system might remove the existing necessity for the conductor. In the meantime we have a proposal to apply electric traction to existing railways in such a manner that no special plant beyond the actual locomotive is required. The engine (at present being constructed on the plan of M. Heilmann) differs from the ordinary locomotive in the fact that instead of the engine proper being coupled directly to the driving axle, it actuates a dynamo, the current from which is utilised to turn the engine wheels through the medium of motors placed directly on the axles.

At first sight it would appear that such an arrangement could only result in loss; but a little consideration will show us that vexatious limits as to diameter of wheels, size of boiler, and length of wheel base disappear, whilst the total weight of the engine can be utilised for adhesion. Coupling rods are not required, and all reciprocating parts can be balanced without the introduction of disturbing forces, in themselves fatal to the attainment of high speeds; and as the efficiency of transmission is high, and the engine can be run continually at the most economical expansion ratio, the fuel economy of the machine will probably be greater than that of any existing locomotive. It has also the advantages of being capable of attaining a higher velocity, and of dealing indiscriminately with express and goods traffic.

Only practical experience can determine whether these results can be obtained without a disproportionate expenditure in first cost and upkeep. At present it would appear that this locomotive is destined to form a link in the chain of transition from direct steam to electrical traction on our railways, but that it will in turn be displaced by a conductor or storage system.

The excessive waste of material which occurs in the stoppage and control of the movement of railway trains is well known, and attempts have from time to time been made to reduce this loss and to obtain some return for the energy given up during retardation. It is a matter for surprise, therefore, that no efficient electrical brake has yet been introduced; by electrical brake being understood, not an arrangement where electricity simply replaces fluid pressure as means for actuating the brake blocks, but one in which there is no frictional contact, the kinetic energy of the train being absorbed in the production of electrical currents. On electrical railways it would probably be found economical to conserve this energy, but for present application such complication would be better avoided.

With respect to steam navigation, the high rate of speed now maintained over long voyages and the regularity with which such

are accomplished are remarkable. These results are, doubtless, in some measure due to an increased size of vessel, but chiefly to the great advance which has been made in marine engine construction. The adoption of high boiler pressures, triple expansion engines, and the free use of steel has enabled the marine engineer to so increase the efficiency of his machinery that we now find 2·4 indicated horsepower per gross ton of vessel attained, as against the one horsepower per ton of ten years since. An indicated horsepower is produced for a consumption of a little over $1\frac{1}{4}$ lbs. of fuel, and the careful proportioning of details has rendered stoppages from breakdowns of rare occurrence.

To the active competition between the great English torpedo boat builders much of this progression can be traced, and the new water tube boiler of Mr. Thornycroft promises, from its comparative lightness, to enable a further stride to be taken in high speed navigation. But is advance in this direction to be completely dependent on the engine-builder? The naval architect has certainly somewhat reduced the weight of the hull, but the form of vessel has remained for many years practically unchanged. The great improvement in the speed of our large racing yachts that (under similar conditions of stiffness and displacement) has followed the adoption of great beam, shallow body, and round lines, points to the possibility of a beamy, pram-bowed vessel of moderate draught being propelled with a less expenditure of power than is required in the case of the pointed tanks now so common. Between the seaworthiness and comfort of the two types there could be little comparison.

It is to submarine navigation we must look for the attainment of extremely high velocities; but if a submarine vessel—in every way as desirable as the creation of Jules Verne's fertile brain—were introduced to-morrow, it is extremely doubtful if it would command a share of traffic sufficient for its profitable employment.

Aerial navigation will in all probability be, before long, an accomplished fact. Messrs. Maxim and Phillips have each succeeded in causing machines carrying their own motive power to lift themselves from the ground, and move through the air at a high velocity. This has been effected in the apparatus of the former by the reaction of a single inclined plane; whilst Mr. Phillips has adopted a series of narrow planes arranged in much the same manner as the laths of a venetian blind. In both cases the machine is propelled by a single stream-driven screw; but it is open to question if the aero-plane surface might not be much reduced, and the manipulation of the contrivance made far more easy, by so arranging the propeller shaft that its axle with the horizontal could be varied at pleasure. The immediate use to which the successful flying machine will undoubtedly be put will be that of increasing the horrors of war, the character of which

its employment must completely change; for cities, no matter how fortified, will be completely open to attack, and treaties notwithstanding the destruction of non-combatants and of private property will be appalling.

In conclusion, I would refer to the long distance transmission of power. Passing over as experimental the now historical installation at Frankfort, where 300 horsepower was electrically transmitted 108 miles, with a stated efficiency of 73 per cent., we find that the adoption of the high tension alternating current system has rendered it possible to transmit power over long distances with commercial success. An electromotive force of 10,000 volts is now recognised as a safe pressure if proper precautions be used. With high pressures the cross section and cost of conductor is greatly reduced. The smallest sized wire having the necessary strength for line work (No. 6, B. and S.) will, at 4,000 volts, transmit 100 horsepower ten miles with 80 per cent. efficiency. When pressures exceeding 5,000 volts are employed it is advisable, on account of difficulties connected with the insulation of the machines, to make use of transformers, the current being raised for transmission at the generator and again reduced at the motor terminals. As transformers having an efficiency of 97 per cent. are now constructed the loss from this arrangement is insignificant compared with the saving in cost of the conductor.

The want of a perfected alternating-current motor has alone delayed the rapid extension of this system; but this difficulty has apparently been completely overcome by the recent inventions of Nicholas Tesla, and has been reduced to a minimum in an installation which has for the last two years been in regular work in America.

At the Gold King Mine, Colorado, power was required for operating crushers and stamps; fuel could only be procured from long distances at enormous cost, but a few miles from the mine water power was available; the intervening country, however, was so rough and so often snowed up that no ordinary means of transmission could be made use of. Electricity was therefore adopted. The plant consists of a Pelton wheel driving an alternating-current generator. The current is carried by a bare wire up the mountain side to the mine at a height of 2,500ft.; here it drives a 100 horsepower synchronous motor, which is started by the assistance of a small motor of the Tesla type. The efficiency of the system was found on test to be $83\frac{1}{2}$ per cent. at full and 74 per cent. at half load, losses in generator and motor, but not those of conductor, included. So satisfactory has been the practical working of the plant that a 750 horsepower generator and a 300 horsepower and some smaller motors have lately been added.

Long distance transmission for lighting purposes has for the last three years been in satisfactory operation at Portland, Oregon. The falls of the Willamette River, thirteen miles from Portland,

are estimated at 250,000 horsepower, 300 horsepower of which is utilised by means of turbines driving two alternating-current dynamos. The current, generated at 4,000 volts, is carried by a No. 4 B. & S. wire on ordinary glass insulators across country to the sub-station at Portland, where it is received at 3,300 volts, and reduced by transformers to 1,100 volts for distribution through the city to ordinary transformers, by which it is again reduced to 50 volts. Additions have lately been made to the plant, the total capacity of which is now 8,750 sixteen-candlepower lights. Works for the utilisation and electrical distribution of the great energy of Niagara are being actively prosecuted.

The immense waterpower of the world is now available, and can be conveyed to situations where the difficulty of procuring fuel has hitherto prohibited mining and other operations. It will be possible for manufacturing to exist far removed from coal measures, and even for industries, the profitable prosecution of which has been dependent on abundant fuel supply, to be carried on without such aid. To the small manufacturer the supply of cheap and readily applied motive power will be a great boon, and we may look for a revival in the prosperity of the small workshops now almost crushed out of existence by the competition of their more powerful rivals. The utilisation of power obtained at a distance may, in fact, be expected to effect a change in industrial operations hardly inferior in magnitude to that brought about by the introduction of the steam engine. I think, therefore, you will agree with me in considering the successful transmission of power over long distances as "the greatest mechanical achievement of the age."

Section I.

SANITARY SCIENCE AND HYGIENE.

ADDRESS BY THE PRESIDENT,

A. MAULT.

URBAN SANITATION.

I.

Ever since men gathered themselves into communities they have found that some laws or regulations were needful to preserve health. Comfort and natural decency perhaps first prompted these laws, but soon safety more imperatively asked for them. Even the temporary camping-place of a nomadic horde would soon become unbearably offensive and unhealthy if its filth and refuse were not got rid of. To get rid of it from the camps of a wandering people was one of the objects of the health clauses of the earliest code of law that we possess: one of the objects, I say, but not the only one. And it is interesting to note how farseeing and foreseeing was the wisdom that prompted the sanitary provisions of the Mosaic law, and based them on what are still recognised as the true foundations of sanitation—cleanliness of person and of dwelling-place, wholesomeness of food, and isolation of infectious disease.

What is needful in a camp with respect to the health of the sojourners therein is still more needful in a city; but the means for securing it are necessarily different in the differing circumstances of a movable and of the fixed dwelling-place of a people. At first these means were very often rude, and not only inadequate, but sometimes calculated rather to endanger health than to preserve it. But the garnered experience of each place, on the one hand, and the results of scientific research and their dissemination, on the other, have, slowly at first, but much more rapidly in recent years, placed matters in a more satisfactory position.

Coincidentally with the growth of knowledge of the best means of safeguarding the public health, there has grown up—I think I may say that there has consequently and necessarily grown up—the principle of leaving less and less to private initiative and control, and more and more to the management of public sanitary authorities. There is therefore to-day, in all civilised countries, a

great body of sanitary law administered by local authorities; and the completeness of this body of law and the thoroughness of its administration is one of the best, if not the best, standard wherewith to measure the real civilisation of a people.

I propose, as an introduction to the work of this section, to address to you some observations on the general scope of the powers entrusted and duties imposed by modern legislation on the municipal authorities who are the guardians of the health of a town community, with illustrations of the means employed by some of these authorities in the exercise of these powers and fulfilment of these duties. In speaking of powers entrusted and duties imposed I hold that in health matters the entrusting with power is the imposing of a duty—that where issues of life and death are involved *may* and *can* should be read *ought* and *must*. Of course the means employed must always greatly depend upon the circumstances of the community under the care of the authorities, as a large and wealthy city may employ a staff and do work quite beyond the capabilities of a small and poor one. But it is none the less interesting and useful to know what may and ought to be done, when financially possible, and it is better to set up a high standard for attainment than a low and easier one. Furthermore, a small community can often usefully modify the means employed by a large one, and thus arrive at the end to be aimed at—the securing and safeguarding the health of the people.

The work of the health board for a town may be broadly divided into the prophylactic, the curative, and the constructive—the first and second being under the direction of the medical officer of health, and the third under that of the engineer or town surveyor. There is no definite boundary between these divisions; and the work to be done often belongs almost as much to one division as to another, and can be efficiently done only by the hearty co-operation of both branches of the service, for much preventive and curative work requires special constructions, and most sanitary construction is undertaken with the view, at least indirectly, of preventing or treating disease.

The duties of the officer of health embrace the measures to be taken to guard the public health generally, and the special means to be used in regard to infectious and epidemic diseases. He needs a staff of inspectors sufficient for the thorough and continuously recurrent examination of the whole of his district, and a material equipment to enable him to deal promptly and efficaciously with infectious diseases as they arise. The sufficiency of this equipment is the principal factor which determines in ordinary circumstances whether an outbreak of such disease shall or shall not assume the proportions of an epidemic.

The town surveyor or engineer's staff should be sufficient not only for designing and superintending the construction of the sanitary works undertaken by the municipal authorities, but also for

the performance of other such work not involving construction, and for the supervision of all house and other building done by private persons, so as to secure good wholesome dwellings, workrooms, and meeting places of all kinds. The tendency of modern legislation is, as I have already mentioned, to leave in sanitary matters less and less to private initiative. The result is that in some large cities the town surveyor's staff is a very important one, and directs a considerable body of workmen of all sorts.

Enactments relative to public health may be broadly classed into measures for securing the purity of the air we breathe; measures for securing the wholesomeness of the food and water we eat and drink; measures for securing the healthiness of the houses we dwell in, or work in, or meet together in; measures taken with respect to infectious diseases; and measures other than these, but which have a general reference to the public health. In connection with all these measures it is interesting to note how they are being more and more based on scientific principles, and how more and more attention is being paid to the investigation of those principles. Much of this investigation is beyond the means of small communities, and has to be undertaken either by the central government of a country or by the local authorities of large and wealthy cities. To some of these authorities much praise is due for the perseverance with which some branches of inquiry have been carried on, not only in directions that have at once proved useful, but also in some that are thus far apparently barren of practical result. Still more is praise due to scientific men in private life, especially to medical men, for their unwearying investigations in matters of such vital importance to their fellow men, for facts and coincidences are being observed and recorded that may yet serve to point out law and order where now all is obscure and seemingly disconnected.

II.

The work to be done by a local board of health, acting as a municipal authority, may be thus summarised in the classes above mentioned :—

(a) MEASURES FOR SECURING THE PURITY OF THE AIR.

1. The determination of the condition of the air, by observation.
2. The removal of superfluous moisture, by drainage.
3. The collection, removal, and proper disposal of sewage.
4. The construction of streets in a manner to be easily kept clean.
5. The proper cleansing of streets and disposal of street refuse.
6. The proper control of offensive trades.
7. Smoke prevention.
8. The proper construction and cleansing of yards and courts.
9. The prevention of over-density of population on a given area.

10. The provision and conservation of open spaces in towns.
11. The removal and prevention of nuisances of all kinds.
12. The removal and proper disposal of refuse of all kinds.

(b) MEASURES FOR SECURING WHOLESOMENESS OF FOOD.

1. The provision of good water in sufficient quantity.
2. The prevention of water pollution
3. The establishment of properly-organised slaughter-houses and control of the meat supply.
4. The control of dairies, milch kine, and the milk supply.
5. The control of bakehouses and the bread supply.
6. The provision and control of fish, vegetable, and fruit markets.
7. The prevention of the adulteration of food.

(c) MEASURES FOR SECURING THE HEALTHINESS OF HOUSES.

1. The control of housebuilding, so as to secure healthiness.
2. The control of the sanitary condition of existing houses.
3. The demolition of unhealthy houses and building of healthy ones.
4. The prevention of over-crowding in houses, factories, &c.
5. The control of the sanitation of schools, factories, lodging-houses, &c.
6. The control of public buildings as regards health and safety.
7. In seaports, the control of the sanitary condition of ships.

(d) MEASURES FOR DEALING WITH INFECTIOUS DISEASES.

1. The establishment of a proper system of notification.
2. The carrying out of special prophylactic measures, such as vaccination.
3. The provision of sufficient special hospital accommodation and ambulance service.
4. The provision of reception and observation wards.
5. The provision, where necessary, of a special medical service.
6. The provision of a properly-equipped house-disinfection service.
7. The establishment of disinfecting stations or provision of movable disinfectors for clothing, bedding, &c.
8. The control of the transport of the sick from the point of view of the public safety.
9. The control of the burial of infected bodies and provision of mortuaries.

(e) GENERAL MEASURES.

1. Infant life protection.
2. The provision of public baths and washhouses.
3. The control of burial grounds.

4. The control of streets, including tramways, lighting, &c.
5. The provision of public parks and recreation grounds and other such like measures.

The time at our disposal forbids much illustration of the work thus summarised, but I will shortly notice some of the measures taken.

III.

MEASURES FOR SECURING THE PURITY OF THE AIR.

In the first place it is necessary that the condition of the air be known. It is liable to pollution both from what may be called natural and artificial causes. Thus the air of a swamp is unwholesome by reason of excessive humidity, and by the results of vegetable decomposition. If a town be built on the swamp, to these natural causes of impurity are superadded those resulting from human occupation. If the town be built on a dry site, these latter causes may be the only ones to be dealt with. Special meteorological, climatological, and microscopic observations not only furnish information of conditions affecting health, but also, when properly understood, may give direction to the efforts to be made with the object of avoiding or controlling changes of condition of the air caused by human occupation. So far microscopic examination of the air does not seem to have yielded practical information to the health officer except in connection with hospital treatment. In the open air the change of condition caused by human occupation is strikingly shown by comparison of town with country air. Records are available for a number of years in connection with the urban observatory at the Hotel de Ville of Paris, and the suburban observatory at Montsouris in a park of about 350 acres. The mean of the observations for the ten years ending 1890 gives 345 as the number of bacteria in a cubic metre of air at Montsouris, to 4,790 at the Hotel de Ville. I have called this "a change of condition" rather than pollution in a morbid sense, as, though it is difficult to suppose that a large quantity of vegetable organism can exist in the air without affecting its wholesomeness, so far no direct relationship has been observed between the prevalence of disease of any kind and the bacteriological condition of the air. The Paris observations are published for every week with tables of the deaths from zymotic diseases and diseases of the respiratory organs, and no series of coincidences can be remarked. Very often there is a sudden rise or fall in the mean number of bacteria found in one week as compared with the preceding—the differences being sometimes equal to 500 per cent.—without any corresponding rise or fall in the death rate of either the week itself or of any subsequent one. Furthermore, after making allowance for the existence in the same *arrondissement*, the XIV., as that in which is the park of Montsouris, of the great hospital of the

Enfants assistés, and other hospitals and asylums, that *arrondissement*, with a density of population only one-third of that of the IV. *arrondissement*, in which the Hotel de Ville is situated, has a rate of mortality that is quite as high.

With regard to drying the air of a town, it is often effected by the work done in laying the ordinary sewers, and shown to be effected by an immediate fall in the death rate from phthisis and diseases encouraged by excess of humidity. Where the land drainage is not so effected it should be done by special works.

The questions of the system of sewerage and of sewage disposal can receive no satisfactory specific answers applicable to all places and circumstances. The answers must depend upon so many different conditions and contingencies that those of each place must be important factors in deciding upon the answer to be given for the place. But there are certain requirements that must be fulfilled in all places. The sewers must be well and economically built, large enough to do their duty, but not too large; they must be self-cleansing, or have special means of being cleansed; and they must be well ventilated; and the sewage must be disposed of without causing a nuisance. The proper fulfilment of all these requirements, especially the last, is often no easy task. Were this the proper arena for such a discussion, and were there time at our disposal, I should be inclined to maintain the following theses:—

1. *With regard to the Sizes of Sewers.*—That they should be no larger than fully sufficient to carry off in the hour of greatest daily flow the sewage and so much of the rainfall as could not be excluded during that hour, as they would thus secure greater efficiency of action with greater economy of construction, better ventilation with a smaller supply of air, and better flushing with a smaller supply of water.
2. *With respect to the Ventilation of Sewers.*—That the best mechanical means for effecting it are those making use of the force of the wind as motive power.
3. *With relation to Sewage Disposal.*—That our present experience shows that where it can be safely discharged without treatment, as, for instance, into the sea, such discharge is the most economical method; that where such discharge is impracticable, the purification of the sewage before discharge by some chemical agent, such as ferozone, that does not add much to the bulk of the deposited sludge, is the most economical method of disposal.

With regard to street construction, the principal object to be attained from a sanitary point of view is to have a surface easily kept clean. From this point of view an asphalted roadway is the best, and a macadamised one, if the road be made at all, the worst, as virtually only offering the choice of having the air polluted by

emanations from a damp surface charged with the impurities caused by the constant passage of animals or by those same impurities in the shape of dust. The cost and the slipperiness of bituminous pavement usually hinder its use. Wood pavement comes next in healthiness, and it, upon comparatively level ground, and stone pavement on steeper gradients, are practically the best. In the cities of Europe every year sees a large development in the use of wood pavement, and as these colonies have large supplies of the woods most suitable for the purpose, it is much to be desired that the streets of our towns should give examples of what these woods—such, for instance, as stringybark—can do in the way of furnishing a good paving material. The administration of the streets of Paris is probably one of the best in the world. It exercises the strictest economy; but, in its ideas of true economy, public health and comfort and convenience are considerations as well as expenditure of money. It has about 10,500,000 square yards of street surface to take care of, of which about 7,500,000yds. are paved in stone; 1,750,000yds. are macadamised; 380,000yds., chiefly footways and gutters, are asphalted; 640,000yds. are wood pavements; and a small portion is yet unmade. The extent of stone paving is slightly decreasing, that of macadamised road is decreasing by more than 30,000yds. a year, and that of wood paving is increasing at the rate of 60,000yds. a year. This is a striking fact, as wood paving is much more expensive to keep in repair than stone paving. The yearly cost of street repairs and cleansing, exclusive of interest on first cost of construction, is about 1s. 5d. a yard for wood paving and macadamised surfaces, 1s. 1d. a yard for asphalt, and 5½d. a yard for stone paving.

The next point is: What is the best method to keep roadways clean? I think all experience shows that street sweeping and watering and the disposal of the sweepings are best done by a direct municipal service, without the intervention of a contractor. Ordinary street sweepings have usually some manurial value, and can usually be easily disposed of, either untreated or mixed with sewage sludge or other matters; but as the collection and disposal of house refuse are most economically done at the same time as those of street sweepings, I will say more about the matter a little further on. I believe also that your attention will be specially called to it by Mr. Hardy during our meetings.

Legislation on the subject of noxious or offensive trades has thrown considerable responsibility upon local boards of health. The classification of these trades into groups, something like the three classes into which French law divides them, would facilitate the proper dealing with the whole subject, and allow of the consolidation of the provisions of such Acts as the Alkali Acts in England and of the various Acts connected with the public health in respect of all noxious trades. The first class of the French law comprises trades that must be worked at a distance from any

dwelling; the second class, those which may be allowed under rigorous conditions as to methods of working in the neighborhood of houses; and the third class, those which may remain there without inconvenience, but which require and are subject to constant inspection. Full schedules of all the classes are annexed to the decree of 1886, which codifies the whole of previous legislation on the subject. These schedules make mention of the special inconveniences, nuisances, or dangers that may arise from each of the various establishments. None are authorised without public inquiry and until the proper technical conditions for avoiding the apprehended inconveniences, nuisances, and dangers have been fulfilled. I may mention, as examples of the classification, that manure works are in the first class, tanneries in the second, and sawmills in the third. To encourage the application of science to diminish the evils of noxious manufactures, such as take special measures to that end may be re-classed. Thus some chemical works, where no absorption of noxious vapor is effected, are in the first class, others of the same nature that apply proper processes to absorb the noxious fumes are put in the second class.

Smoke prevention is in many places of great importance. The not undertaking of it by a local board of health, on the ground that the prevention of smoke interferes with trade, is basing inaction on a very futile plea, as the law in regard to it is most vigorously carried out in cities like Birmingham and Manchester, where large manufacturing interests are concerned, and least vigorously in places like Hobart, where only small interests are concerned. Naturally the evils arising from smoke are greater in damp climates than in our drier ones. The observations being carried out in London and at Manchester are specially interesting, particularly with regard to the connection of smoke with town fogs.

Of even more importance than the cleansing of the public streets is that of house-yards and courts, and the condition of these places is the crucial test of the effectiveness of the sanitary administration of a town. They are the inside of the cup and platter, of which the streets are the outside. The back doors and back windows of houses are their chief means of ventilation, and the quality of the air that enters by them depends upon the condition of the yard. Where a yard belongs to one householder, proper inspection by the health authorities may secure its cleanliness; but where its use is common to several houses, the only effectual way to secure its cleanliness is to make its cleansing part of the regular scavenging work of the town. This is done with the best results in Edinburgh, Glasgow, Liverpool, Manchester, and other large cities; and leaving it to be done by owners or occupiers is marked by correspondingly bad results in other places I could name. The character of the surface of the yards is the most important factor in the ease or difficulty of keeping them clean. The paving of

them with natural or artificial asphalte puts them into the best condition. It not only makes the surface that is most easily cleaned, but its imperviousness prevents rain and house slops from soaking into the soil, and carrying surface impurities that pollute the ground air that finds its way into the neighboring house. Much of the disease in the older colonial towns and villages is caused by the fact that, for some generations, that part of the sewage which is represented by household slops has been thrown out of the back door, and that consequently the soil upon which the house stands is sewage-sodden, and the ground air tainted. This making of the back yard into the slop and refuse receptacle of the houses causes probably the worst evils attending over-occupation of the ground of towns.

The influence of the density of the population of a given area on the health of that population is well known. The precise conditions under which arose the most flagrant instances of overcrowding are not likely to recur on this side of the world; but the value of land in the larger cities is having the effect of encouraging the building of many-storied houses. The greatest density of population that I have heard of occurred in the Cowgate, at Edinburgh, with 900 people to the acre. An area in Dundee had 724 to the acre, with a yearly death rate of 58·4 in the thousand. These were small areas; but in Glasgow there were 88 acres with 574 people to the acre. In these cities, and in Birmingham, Liverpool, London, and other places, much has been done under special Acts or under the Artizans' and Laborers' Dwellings Acts in the way of clearing out these nests of disease, and with marked effect on the health of the people. The death rate of the areas dealt with in Birmingham fell from 53·2 in the thousand to 21·3; and in these colonies all of us who have to do with the conservation of public health know places where wholesale demolition and rebuilding are the only effectual remedies for the present unhealthy condition of things.

In connection with the prevention of over-density of population, the establishment and keeping up of public parks and open spaces is of great importance. The neglect of public authorities at home to do this in the past has thrown a great burden on the present generation. Let us, wherever there is time and opportunity, follow the excellent example of the founders of the city we are meeting in, when they reserved the belt of park lands. Such a belt is to my mind better than the same area of land in one block or park, just as securing wide tree-planted streets and boulevards is better than the formation of extra urban parks. Have both if possible, but begin with the streets. In nearly every city chances continually occur, and are continually lost, of securing and planting odd nooks and corners in the more thickly-peopled districts.

When all the work thus far mentioned in connection with securing the purity of the open air have been carried out, there

remains yet to be done what is practically the most important function of the health authority—the seeing that sanitary duties are properly performed by owners and occupiers of urban property—the function of the inspector of nuisances. The way in which this function is performed is another crucial test of sanitary administration. The more continually and effectively the inspection is done, the less necessity is there to enforce the law by legal proceedings. In Birmingham in 1890 in 21,342 cases nuisances were abated on notice being given, while in only 57 cases was it found needful to enforce the notice in the police court; and in Liverpool last year in one class of nuisances over 93,000 were abated on notice, and only 122 enforced by law. The principal factor in the success of an inspector's work is the knowledge that it is unremitting.

When a district requires a number of inspectors it is very desirable that some of them should be women, either directly engaged and employed by the health department, as at Glasgow, or authorised by and acting under its control, though working in connection with benevolent societies, as at Manchester. The object of inspection is twofold—the finding out of matters that require attention, and the seeing that they are attended to by the fulfilment of the preventive measures ordered. With regard to the first-named object experience has shown that women are in many cases more efficient than men, and naturally so. At the time inspections are usually made in the houses of working people the men are away, and the women at home are reticent—and not improperly so—with men inspectors, and consequently the men have to find out everything for themselves; but if women inspectors come, their inspection is greatly assisted by the freedom with which information is given them.

There are two circumstances connected with this subject that are greatly to be regretted. They probably are mutually explanatory the one of the other. The one is that people in general take so little pains to give the health authorities information of what it is urgently important that they should have knowledge. As in many other things, we are in this ruled by false sentiment. We hold that it is an unneighborly act to tell the inspector that our neighbor's children have diphtheria: but we do not hold that it is unneighborly to let the children of fifty other neighbors take their chance of catching the infection. The other circumstance is that sanitary authorities, when necessary information is tendered either by persons or societies, seem to regard the matter as an interference with or a reflection upon their performance of their duty. The work of preserving the health of the people is so important that everyone should work to secure it, and everyone's help should be heartily accepted.

With regard to the disposal of all the refuse of households and of the trades and occupations of a city, including slaughter-house

offal and market-place garbage, the most effectual and harmless way is by burning in properly-constructed furnaces or "destructors"; and the most dangerous and objectionable way is to use it to fill up claypits, quarries, and such like places in the neighborhood of cities.

As far as my observation and experience go, the quantity of objectionable refuse to be treated in a year amounts, in the larger English towns, to about 12cwts. or 13cwts. for each head of the population. Well designed and built destructor furnaces, such as Fryer's, will burn about 8 tons a day in each cell; so that one destructor cell is required for each 4,000 of a population. If the heat that is generated in the destructor be utilised for steam production, and if the steam power and clinkers resulting from the burning be profitably employed, as at Southampton, this method of the disposal of town refuse may be said to cost nothing. I am not speaking of the cost of collection, as the refuse has to be collected however disposed of. If no use can be made of the heat or of the clinkers, the cost of destruction will be, including interest on outlay, repairs, and labour, about 1s. a ton, or $7\frac{1}{2}$ d. a year for each head of the population.

As the greater part of the expense of refuse disposal is connected with its collection, it is important in large towns to distribute as much as possible the emplacement of the destructors, so as to reduce the length of the cartage. It should also be borne in mind, when selecting destructor sites, that cartage uphill ordinarily costs 50 per cent. more than cartage downhill.

IV.

MEASURES FOR SECURING WHOLESOMENESS OF FOOD AND WATER.

The principal constructional work in this section is connected with the water supply of towns. We hope to hear something about the supply of the city we are meeting in from a very competent authority. I will only generalize. In these dry Australian climates the procuring and conserving of a good water supply is a matter the difficulty of which becomes the greater almost in geometrical ratio to the increase of population. The first difficulty may be as to quantity. The increase of the population means the disafforesting of the country, and that in turn means the decrease of rainfall, that is of water supply. On the other hand, where sufficient quantity is obtainable from forest-covered land, the quality of the water is apt to be deteriorated by the presence of excessive quantities of albumenoid ammonia and impurities resulting from vegetable decomposition. In such cases it should certainly be purified before being delivered for consumption. A matter to which too little attention is usually paid is the necessity, or at

least desirability, of having both dark and cool storage for water. Service reservoirs should always be covered, and distributing mains laid low enough in the ground, and house pipes kept from direct sunshine.

A matter connected with country rather than town water supply that I should like to see taken into consideration is the probable influence of rain-water drinking on our population. Are there not signs that it is being physically affected by its use of soft-water drinking?

The whole matter of water supply should be in the hands of the health authorities. But even when it is, there is none the less a necessity for constant inspection. The services, both chemical and microscopical, of the analyst should be exercised not only in connection with the choice of a supply, but continuously afterwards in connection with the water actually drawn out of the household taps. Constant inspection, both for the prevention of pollution and for the detection of it when it does occur, is still more needed when a community is dependent for its water supply upon a variety of sources, such as wells, small streams, and rain-water tanks.

With regard to the meat supply of a people, the most effective way to control its wholesomeness is to provide properly designed and built public slaughter-houses, in which alone should be allowed the slaughtering of animals intended for food. In such establishments the measures to be taken to prevent the use of unwholesome meat, and meat that may be the vehicle of the contagium of diseases that are communicable from animals to man, can be most easily and effectively carried out; and so also can those for preventing the nuisances that usually accompany the keeping and killing of animals.

Too much attention cannot be paid to the sources of the milk supply of a people. The results of thorough organisation and inspection are well exemplified in Denmark. The people of Copenhagen have not only the best milk supply of any large community, but the dairy produce commands—and deservedly commands—the best price in the largest markets in the world. This with some people is the ultimate gauge of success, and precautionary measures which might be characterised as excessively stringent, when taken merely for protecting human life, are held to be justified by their influence on the far more important matter of commercial profit. Some of our colonies have special laws dealing with dairies from the standpoint of public health. Others are trying to open a trade with England for butter and cheese. The securing of absolute cleanliness is the most important factor in the securing of success in regard to both these matters.

The inspection of milch kine is also very necessary. However much medical opinions may vary as to the dangers attending the consumption of the meat of tuberculous cattle, I think there is no difference of opinion as to the necessity of preventing the use of the milk of tuberculous cows.

The great points to be attended to in connection with all structures having to do with food supply—whether slaughter-houses, cowhouses, dairies, bakehouses, meat or fish or vegetable markets—are to build them of materials and on a plan easily kept clean, and to provide in connection with them proper means of disposing of all their refuse—solid or liquid.

Proper inspection of fruit and vegetable markets is usually much neglected. At Glasgow, New York, and Paris properly organised services for this purpose do much good.

The detective work carried on by the public analysts of the local boards of health is very important. The results of this work in Great Britain, that can be definitely appraised, are the great and steady diminutions that are continuously occurring in the numbers of adulterated articles among those submitted to examination. The precise effect of this diminution of adulteration upon the public health is difficult to exactly determine, but what is sure is that the public health has improved *pari passu* with the improvement in the purity of food.

V.

MEASURES FOR SECURING THE HEALTHINESS OF HOUSES.

New houses are comparatively easily dealt with where there are proper by-laws and regulations setting forth the conditions under which they may be built and occupied. The sanitary portion of these by-laws should not only regulate drainage and ventilation, but should have regard to the nature of the site on which a house is to be built and the open spaces that are to be left about it, and should insure its thorough inspection and the testing of its drains before its occupation. This is done in many towns with very useful results, the experience of New York illustrating what I have said as to the efficacy of unremitting inspection. At first the notices served had frequently to be enforced by legal proceedings; but soon the astute builders of the empire city found out that it was cheaper to fulfil the building regulations than to try to evade them. I am sorry that my experience of colonial life shows me that the great want is not provision of good laws and regulations, but of steady determination to enforce them.

There is more difficulty in dealing with the unhealthy condition of existing buildings. This difficulty arises not so much from the impracticability which often exists of effectually remedying structural defects as from financial considerations in connection with the fact that unhealthy dwellings are, as a rule, occupied by the poor, and are often owned by them. Improving them usually means raising their rents; demolishing them often deprives the poor of homes near their work. To the evils arising from the actually unhealthy condition of a house are often added those arising from overcrowding. The poorer a family becomes the less accommoda-

tion it can afford for itself. The scant accommodation often becomes scantier by the giving up of some of it to lodgers—the last resource of a poor housewife to eke out her means. The difficulties attending the dealing with these poor houses have been more resolutely, and I believe therefore more successfully, faced at Glasgow than in any other large city I know. As far back as 1862, under the provisions of a special Act, all houses of not more than three rooms, and with a total cubic space of not more than 2,000ft., were placed under special sanitary observation, were measured, and allowed inmates at the rate of one adult or two children under ten years of age for every 400 cubic feet of space, the allowed number being stamped upon a tin ticket on the door. These “ticketed houses” are liable to and receive inspection by night as well as day, and their sanitation has done marvels in improving the health of the city.

In my own experience I have found that in hard times, such as these we are now unhappily having, the sanitary condition of the poorer classes of houses rapidly deteriorates. Landlords get less rent from such property, and therefore spend less upon it. The tenants pay their rent less regularly, and therefore can demand less in the way of repairs, however necessary. A sort of tacit understanding on this matter is arrived at; but in some cases it is openly expressed. A family as it goes down in the world gets less and less exigent as it descends the social scale, until its refuge is a place the landlord will let them have only on condition that he is not to be asked to do anything. To meet such and such like cases we are in Tasmania asking Parliament, among other amendments of the Health Acts, to apply to existing houses on change of tenancy the provisions as to inspection and certificate before occupation that are elsewhere in force with respect to newly-built houses. We hope by this means, not only to prevent the letting of houses in an unhealthy condition, but also to effect good with regard to poor houses under existing tenancies, as landlords may as well do repairs for the present tenants as be obliged to do them for new ones.

In many cases the only practicable remedy for the unhealthy condition of a house, or group of houses, is the drastic one of demolition. Reference has already been made to the good work done in many places by exercising the legislative powers granted to this end. As important is the exercise of the legislative powers granted for reconstruction. The results following this exercise at Birmingham, Glasgow, Liverpool, and London, under powers obtained under special Acts, amply justify the granting of similar powers to all urban sanitary boards as effected by the Housing of the Working Classes Act of 1890. The building work thus authorised has not only done good directly to the people who have actually been provided with improved dwelling-places, but indirectly also by raising the standard of cottage and house building over whole districts.

I need not enlarge upon the sanitation of lodging-houses, schools, factories, and public places of all kinds, such as churches and theatres. It is in principle similar to that of dwelling-houses.

VI.

MEASURES FOR DEALING WITH INFECTIOUS DISEASES.

Whatever may be done with relation to ordinary diseases, the State claims the right to interfere in the case of infectious disease, as its treatment concerns every one within reach of the infection. The tendency appears to be towards increasing the number of the diseases to be classed as infectious. This is the case in America, where phthisis is, in some sanitary administrations, so classed.

As regards notification of infectious diseases, the yearly reports of the medical officers of health of many of the large towns in Great Britain continually call attention to the beneficial effects that have followed the adoption of the Infectious Diseases Notification Act, 1889. As far as I know, it is only in the United Kingdom and in this colony of South Australia that any fees are paid to medical men for notification; and here I understand that, as the fees are only paid on notification of smallpox, cholera, and yellow fever, the payments are seldom or never made. My own opinion is that this list should be extended to embrace other diseases in which immediate preventive measures are known to be effectual. As it is certain that in such cases early notification of every case is one of the most important factors in the success of such preventive measures, such notification is worth securing at some cost and should be obligatory. If it be not the cases that are most likely to spread infection, such as those occurring in inns, lodging-houses, dairies and retail shops will not be notified.

As to special prophylactic measures, such as vaccination, I will not occupy your time, but only express my regret that in some of these colonies, as our governments must surely recognise the value of the operation, they do not seem to have the courage of their opinions and insist on its performance.

As regards hospitals for infectious diseases, our attention will, I understand, be specially directed to the provision that is made in this city of Adelaide. It is certain that the knowledge of the proper construction and proper administration of them has made great advances in recent years. The establishments and services of the Metropolitan Asylums Board in London, and of the city authorities at Glasgow, are especially complete. As an example of good construction, I may mention the floating hospitals for smallpox on the Thames, where the difficult problems of warning and ventilation have been solved with singular success. In the comparatively large wards the air is renewed every seven minutes without creating draughts. The only negligence I would remark upon is that the outgoing air is not subjected to any antiseptic treatment—a very

important matter in relation to the outgoing air from a smallpox hospital. The omission could be easily remedied, as means are at hand for super-heating steam.

At Glasgow provision is made, not only for the patients, but in some cases for their families in reception or observation wards connected with the hospital establishments. Observation wards for doubtful cases are very useful adjuncts to all hospitals for infectious diseases. The proper construction of ambulances for the transport of infectious cases is very important, but still more important is the proper regulation of their work and service.

Hospital treatment, though primarily intended for the cure of disease, is certainly one of the most effectual means of preventing its spread in highly infectious cases, such as those of scarlet fever, as in the removing a patient the source of infection is removed from a family. Probably the diminished death rate from scarlet fever of recent years in Great Britain is due to hospital isolation and treatment, as diminished death rate from smallpox is due to vaccination, diminished death rate from typhoid fever to sewerage, and diminished death rate from diarrhoea to improved water supply.

With respect to hospital accommodation for infectious diseases that should be made in large cities, it is probable that a permanent provision of one bed for each 1,000 or 1,200 of the population would be sufficient. The present provision in London is about one bed for each 1,400. In Aberdeen, Birmingham, Edinburgh, and Glasgow it varies from one for 1,000 to one for 1,200; while in Cardiff it is only one for 2,500, and in Dundee one for each 4,000 of the population.

In small communities I should advise that provision be made of a proper site, with such preparations as would enable the Health Board to at once isolate the more serious infectious cases when necessity arose. At Launceston we have secured twenty acres of suitable and easily accessible land about three miles from the centre of the city. The site is high and well wooded, and has a sandy soil over gravel. An acre in the middle of it is surrounded with a high fence, within which are arranged concreted and asphalted platforms to receive hospital huts or tents; and drains are laid and water supplied. Hospital huts could be put up at a few hours' notice, and tents immediately. I believe this to be the most economical way for such a community to make preparations against, say, a visitation of smallpox, as no staff is required until the emergency arises. Beyond this, provision of a proper ambulance should be made and its service organised.

The proper disinfection of houses in which cases of infectious disease have occurred is a matter that cannot safely be left to private enterprise and responsibility. It is one that can be more efficiently as well as more economically done by a staff of trained workmen, who can, moreover, do the work with safety to themselves.

The disinfection of clothing, bedding, and furnishings of all kinds requires special apparatus, either fixed or locomotive. All experience is showing more and more clearly that disinfection by heat is more efficacious than disinfection by chemicals; consequently hot air or steam should be used wherever practicable.

It is proposed by some to apply the principle of disinfection by heat to the bodies of those who have died of infectious diseases. This is hardly likely to become a general practice at present, though it seems that cremation is slowly coming into favor; but as regards the burial of infected bodies, some regulation is necessary both as to time and method. The earliest practicable burial should be insisted on, due precautions taken for the disinfection of the body and coffin, and the use of vaults strictly forbidden. I would that it were forbidden with respect to all burials.

VII.

ADMINISTRATION.

The proper carrying out of all this sanitary work by the medical, engineering, and inspecting staff is rendered possible or impossible by the manner and spirit in which it is regarded by the general or local government under which it is undertaken. Unfortunately its importance is generally under-estimated, especially in young communities. It would be natural to suppose that the offshoots of older civilised peoples would, after they had fairly settled down in new countries, continue the work of sanitation from the point arrived at in their old home. But no. It seems that our race is determined at every fresh settlement to ignore the experience of its past, or to deem that its new circumstances are so exceptional as to render that experience worthless. Sanitarians are thus constantly told, "That is all very well in England, but it is quite unnecessary here." So the old battle against preventible disease has to be fought all over again, not only in every country, but almost in every town in it. There is frequently no definite Government policy in health matters, and no generally expressed public opinion asking for such a policy. The consequence is that the financial difficulties in the way of sanitation are greatly aggravated. From no point of view is the truth of the old saw, "Prevention is better than cure," more forcibly illustrated than from the financial one. A small sum judiciously and continuously spent in preventive measures will—altogether apart from saving life and diminishing suffering—often amount to far less than the cost of the measures taken to meet a scare. Some years ago we had such a scare in Tasmania. A few cases of smallpox occurred in Launceston—thirty-three, with ten deaths. The Vaccination Act had virtually become a dead letter, and there was consequently a little panic. The other colonies quarantined us; our postal and shipping services were greatly

embarrassed; and our commerce suffered severely, and its monetary loss I cannot appreciate. But apart from it the Government spent about £9,000 in dealing with the outbreak, of which about £1,000 was for gratuitous vaccination. Apart from this £1,000 (which may be said to have been expended in giving immunity from smallpox to about 10,000 of the population of the island) none of the money was spent in preventive work; and at the end of the outbreak, with the exception named, the colony was just as open to the inroads of the disease, and just as unprepared to meet it, as at the beginning. I am not finding fault with the spending of this money: the outbreak had to be dealt with at any cost. What I find fault with is that it is not thought worth while to prepare beforehand, by having a definite policy in regard to the prevention of preventible disease—and smallpox is eminently a preventible disease. If the Vaccination Act had been duly administered, and if there had been an infectious diseases hospital at Launceston, I am convinced that £1,000—that is, £30 a head for the patients treated—would have sufficed to have stamped out the disease.

As might be expected, local boards of health are often still more short-sighted than Governments. Every member of some of the boards appears to think, with respect to health matters, not that he is bound to protect the interests of the ratepayers in every possible way, but in one particular way—to protect them from paying a sanitary rate. I know cities, undrained cities, where the yearly monetary loss, measured only by the time lost by bread-winners from typhoid fever, would pay for their thorough drainage in four years, and yet where nothing permanent is done to remove the causes of typhoid fever; and there are not a few places where comparatively large sanitary rates are paid—I will not say are cheerfully paid, for who does pay rates cheerfully?—but paid year after year to carry out the pail system, without any provision being made for the disposal of household slops and the rest of the sewage, where a proper system of sewerage would dispose by water carriage of both the solid and liquid portions of the entire sewage, and would need no larger a rate to pay for it. And thus not only are the larger economies of life, and health, and comfort sacrificed to the smaller economies of ratepaying, but the smaller economy itself is sacrificed through ignorance and short-sightedness.

On the other hand, I do not know of any health authority that has fairly, manfully, and intelligently faced the whole problem of the sanitation of the place and people committed to its charge that has not justified its action by success that can be appraised in money, as well as in the far more important successes that are priceless in the way of lengthening life and increasing comfort and lessening pain and suffering. I hold that business matters in which monetary profit and loss are the main concern are best left to private undertaking; but in health matters the standard of

profit and loss is on a higher footing—though the monetary phase of it must not be disregarded—and the undertaking of all that concerns these matters is best left in public hands; and I am not disposed to curtail the bounds of the matters that concern the public health. For instance, I would include some matters that may be said rather to affect public comfort and convenience than health. I have referred to the condition of the streets and roads of a town as an important factor in the matter of its health. I would therefore advise that everything connected with that condition should be under the control of the authorities—paving, cleansing, sewers and drains, water mains and services, gas mains and services, tramways, tree planting, and such like. I would do so all the more on account of the commercial aspect of some of these undertakings, for commercial considerations might require that streets should be dealt with in one way while public health and convenience might require something different. Some of us who have had experience in street making and maintenance know the annoyance and evils connected with the joint occupancy of a roadway by water and gas and tramway companies, all claiming rights interfering with the duty of the town authorities to maintain the surface in good, safe, and clean condition. Moreover, the proper administration of all these matters not only prevents the annoyances and evils referred to, but secures to the public a better service than can be attained when trade profit is the main consideration, and at the same time secures the profit also. For instance, the city of Birmingham acquired the gasworks by purchase in 1875. Since that time the chief point aimed at has been the making of a gas as free from impurities and of as high an illuminating power as practicable. And not only has this been secured, but the price of gas has been reduced from 3s. 6d. a thousand feet to small consumers to 2s. 7d., and at the same time a profit averaging £50,000 a year has been made, half of which has been placed in a reserve fund and half gone in aid of the general improvement rate of the city. "The ratepayers of Glasgow," as Dr. Russell says, "through their representatives, not only purvey their own water, gas, electricity, and street locomotion, but under the force of circumstances are becoming holders and purveyors of house accommodation," and, I may add, the ratepayers are finding it quite worth their while to do all this.

I would be willing to base the whole case in favor of energetic administration of health laws upon the arguments to be drawn from the example and experience of the proverbially shrewd and practical men of Glasgow. They have not only done what Dr. Russell mentions, but have carried out all that the health laws of the country empower them to do; and where they found that the provisions of the general law were not sufficient, they have promoted special sanitary legislation for their city. There are no less than twelve such special Acts on the statute rolls of Parliament.

They have fulfilled my ideal of administering such laws by reading permissive clauses relative to life and health as mandatory. They have endowed their city with an executive guided by eminent intelligence and actuated by ceaseless energy, and have equipped that executive with all the means that Science recognises not only as essential, but also as helpful, to safeguard the health of a great community. Their reward has been that their city, whose "wynds were a byword among strangers, and a scandal in the eyes of all thoughtful citizens for generations," has become a pattern of health administration, and an example of the success that attends well-directed and persistent effort to improve the material and physical wellbeing of a people.

Section J.

MENTAL SCIENCE AND EDUCATION.

ADDRESS BY THE PRESIDENT,
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Prof. of Mental and Moral Philosophy, University, Melbourne.

RECENT PROGRESS AND PRESENT POSITION OF
MENTAL SCIENCE.

Last year the Section of Literature and Fine Arts made an effective exit, and to-day the Section of Mental Science and Education makes its entrance on the platform of the Australasian Association for the Advancement of Science. Hitherto papers on education have been submitted under the disguise of the Section of Literature, and an occasional paper on mental science has found listeners under some other subterfuge; but now, for the first time, these important subjects are openly recognised. We may, I think, congratulate the Association on the step in advance which it has taken, and may cordially invite the co-operation of all who take an enlightened interest in the study of mental science, or in the theory and practice of education, to make the new departure a success.

These topics are, it is evident, very closely allied. A science which proposes to throw light on mental facts, and which includes, therefore, the consideration of attention, habit, memory, imagination, reasoning, and the emotions and desires, has an intimate bearing on the question of the best methods of educating the powers and capacities of the human mind; and the teacher who from month to month and year to year has had ample opportunities of watching the development of the young, or of imparting special knowledge, may in his turn contribute important facts and generalisations to psychology. From this point of view the subjects may be fitly bracketed together. I shall not attempt, however, in this inaugural address, to take even a general survey of the theory of education; but, leaving this to others who may come after me, shall be content if I can throw some light on the present position of mental science.

In the history of British thought, psychology—or the science of the facts of mind—has been intermingled with metaphysics, or philosophy in the stricter acceptation of the words, as denoting the theory of first principles. The name of Locke, for example, will be long remembered as that of one who gave a powerful impetus to the study of mental science; but while he adopted the psychological method of observing the facts of mind, in so far as he could read these in himself or decipher them from the language and acts of others, his chief aim was philosophical. His purpose, as he said, was to inquire into the origin, certainty, and extent of human knowledge. In the spirit of natural science he sought to observe, analyse, and classify the mental facts before him, and to ascertain their sequences and co-existences; but, in doing so, he sought also to solve questions as to the first principles of knowledge and of reality as known to us, and the questions which he raised were answered by his successors in ways which would have astonished him. Coming down to the Scottish school, whose tenets were in vogue in the first half of the present century, we find that it also represented philosophy as an inquiry into the human mind, requiring careful observation of mental facts; but, above all, it aimed at the establishment of first principles, principles of common sense or primary beliefs, which might be accepted as ultimate criteria of truth. Even by J. S. Mill and Bain we find inquiries into mental facts, and questions of the origin, the validity, and the limits of human knowledge, mingled together as parts of one science; and, in fact, the vague name mental philosophy which is in use to-day, and which has so often been defined as the science of mind, testifies to the common practice of binding questions of mental fact which belong to psychology with philosophical questions which relate to the first principles of knowledge and of being.

Now, there can be no doubt that the endless conflicts of philosophic thought have generated a profound distrust of the methods and conclusions of philosophy. Many fail to see that from the discussion of centuries any solid ground of vantage has been gained, and when they try to enter into these controversies for themselves they feel—

As on a darkling plain
Swept with confused alarms of struggle and fight,
Where ignorant armies clash by night!

Men of science in particular ask for the positive results to be obtained by generalisation from authenticated facts, or by demonstrative reasoning; and, dominated by this craving, they are apt to set aside the questions of philosophy, not only as lying beyond their special quest, but also as in themselves unprofitable or insoluble. I may be tempted to ask, in the sequel, if this is reasonable. The fact, at least, is notorious. And so closely have the fortunes of psychology been bound up with those of philosophy, that both have fallen under the same suspicion. Thus, I think,

we may account for the curious circumstance that the science of mind, supplanted by its younger sisters, has been hitherto neglected by our modern Associations for the Advancement of Science.

The events of recent years are, however, significant of change. Psychology is now separated from philosophy, and is based, like other natural sciences, on a survey of positive facts. Starting with the common sense distinction between mind and matter, it is the task of empirical psychology to deal with mental facts, leaving material facts to sciences which may be comprehensively classed under the heads of physics, chemistry, and biology. The facts of mind, like those of matter, are to be observed and classified; the complex are to be analysed into their simpler elements, and their conditions and the order of their occurrence are to be ascertained. A science of psychology, thus formed, has special features of its own. It proceeds, in the first instance, by means of introspection or self-observation, without which any advance would be impossible; for our own minds are known to each of us individually, while we can only infer what passes in the minds of others. It is compelled also to classify aspects of mind rather than separate facts, for the same complex fact may include knowledge, feeling, and will. These peculiarities, however, do not invalidate its claim to be a natural science. Like other natural sciences, it seeks to arrive at facts and their uniformities; and, like them also, it begins with assumptions—such, for example, as the independent existence of the material world, which it does not profess to investigate. The modern psychologist has, doubtless, his philosophical creed as well as another, and it may creep in where it is not wanted; but he acts wisely when he tries to keep the questions of philosophy out of the way, confessing frankly that any assumptions which he may make provisionally are to be handed over to another court for ultimate judgment. However opposed psychologists may be to each other in their philosophical tenets, they have thus found it possible to maintain an armed truce, and to unite in doing excellent work. In such circumstances psychology justly claims to be affiliated with the other sciences. Nay, the attitude which she assumes in asserting a temporary independence may contain a lesson for them also, for they are all branches of one tree of knowledge—ways which part and divide themselves, as Bacon said from the main and common way of *philosophia prima*, and there is not one which does not move forward on assumptions which may be called to submit themselves in the end to the criticism of philosophy.

The new conception of psychology involves an extension of its territory. The older psychology was almost entirely restricted to the consideration of the adult human mind in its normal manifestations; and each observer was disposed—naturally enough—to regard his own mind as typical of others. The development of the human mind from earliest infancy is now more distinctly recognised

as forming part of the problem. It is seen, too, that even in their normal working minds differ from each other more widely than was at one time supposed. Galton has shown, for example, by his statistical inquiries, that imagination differs so greatly in different minds that in some it is the constant and vivid accompaniment of thought, while in others thought may proceed without the reflective consciousness of any representative image. In the light of such facts as these the old controversy of conceptualism and nominalism wears a different complexion. Then we have the singular phenomena of number forms, or visual images, which in some minds accompany any arithmetical calculation; while in some cases, again, the imagination is auditive rather than visual, as in the case of the wonderful mental calculator Inaudi, who is said to hear his figures as though they were whispered in his ear. When we extend our survey to various races and climes, other differences emerge. These are of practical as well as theoretical importance, for the philanthropist or doctrinaire who sits at home at ease may be so bent on the kinship of human nature as to neglect most important differences; he may be ready, perhaps, to extend trial by jury to Malta, or Parliamentary representation to India, disregarding differences of mental powers or habits. Folk-psychology, as it has been called, may ransack all the ages for its materials, turning to its use all that history or ethnology may contribute. The manifestations of mind in the development of the race, no less than in the development of the individual, thus fall within the scope of psychology.

In recent years, also, intellectual activity has been largely expended in the study of abnormal facts of mind. In the various forms of insanity and hallucination, in hypnotism, in cases of amnesia and multiplex personality, in the alleged facts of telepathy and other phenomena usually classed as spiritualistic, there has been an immense amount of special work. Hypnotism has already to a large extent passed from the hands of the showman and the charlatan into those of the man of science. Here, as elsewhere, the first desideratum has been to make sure of the facts; the next, to interpret them. The tendency of recent investigation is to range many of the most important facts of hypnotism in line with the more normal phenomena of suggestion, but it must be admitted that many of the phenomena cannot be brought under this formula, and await interpretation. The therapeutic value of hypnotism still gives rise to controversy, but it may at least be said that the facts are now open to scientific investigation. The Society for Psychical Research has chosen for its special task the exploration of "various sorts of debatable phenomena which are *primâ facie* inexplicable on any generally recognised hypothesis." These, including the alleged phenomena of thought-transference, clairvoyance, and spiritual manifestations have, till recently, been the happy hunting-ground of the impostor and his dupes. There

is a danger even for cultivated minds of attaching an exaggerated importance to puzzling phenomena, and of over-credulity; and the risk is greater when inquiries are undertaken by those who are devoid of the requisite knowledge of nature, and of human nature, and of the resources of the *prestidigitateur*. But yet it must be recorded with satisfaction that attempts are being made to verify and classify the facts in the spirit of exact science, with a view to their ultimate explanation. We are entitled to set aside as unworthy of credence every statement which shuns the light of scientific inquiry; the carefully guarded circle and the darkened room may be left unentered; but, on the other hand, Science must not shrink from the task of examining all alleged phenomena, whether physical or psychical, which challenge her verdict. Imposture may thus be mitigated, and any residual phenomena which remain must be worthy of attention on their own account, as well as in their bearing on other facts of mind.

Psychology, in its crudest form, has always contained some reference to the bodily organism. The reflective separation of mind from body was, indeed, the beginning of mental science. And it is clearly impossible, in classifying sensations as states of consciousness, to describe the sensations of vision without reference to the eye, or the sensations of sound without reference to the ear. Such obvious connections as these led to more minute inquiries into the connection of mind with the mechanism of the body; but it is only within the lifetime of the present generation that physiological psychology has assumed much scientific importance. Phrenology having been set aside as an ambitious, but inadequate, attempt to exhibit the correlations of mental and cerebral facts, a new beginning has been patiently made. How, and to what extent, do organic changes condition the facts of mind? In this inquiry all the available resources of observation and experiment have been brought to bear; but when we consider the vast complexity of the nervous system, and especially the complex inter-connection of the cells and fibres of the brain, and, further, the difficulty of experiment on the living body, it is not surprising that with all the industry and ingenuity that have been shown progress has been slow. The problems of the neural conditions of sensation and voluntary motion have been attacked with a large measure of success; but in other respects the study is still in its infancy, and abounds with hypotheses to be verified or disproved. It is of little consequence whether we regard neuro-psychology as a special branch of psychology, or whether, with Herbert Spencer, we describe it as a unique science lying midway between subjective psychology and physiology, taking a term from each, but not to be identified with either. The place which it occupies in a classification of the sciences must be dictated by our convenience. In any case modern psychology cannot leave it untouched, and we may certainly lay claim to it as falling under the jurisdiction of the

section of mental science. If it be treated at all in the proceedings of the Association, it will be here.

Under the general title of physiological psychology it is usual also to include psychophysics, which has been principally occupied with the relations between sensations and their extra-organic stimuli. In fact, it has been found convenient to group together all those subjects to which the method of external experiment may be applied, including the time occupied in nervous processes and the correlated mental facts, and experiments on memory and association, as well as the localisation of the cerebral conditions of mind and the laws of physical stimuli. The importance now attached to these subjects is indicated by last year's meeting of the International Congress of Experimental Psychology, attended by over 300 persons, and divided into two sections, the first occupied with neurology and psychophysics, and the second with hypnotism and kindred questions. The experimental nature of these studies should have a special attraction for a scientific association; and I would appeal, not only to this section, but also to the Association generally, to encourage the systematic prosecution of such studies in Australasia. Neither psychology nor philosophy can afford to neglect researches which are now carried on in the psychological laboratories of Germany and America, and the time may come when such appliances may be deemed as essential a part of a modern university as the physical, the chemical, or the physiological laboratory. The first psychological laboratory was established at Leipsic by Wundt, in 1879, and the example has since been followed by other centres in Germany and in the United States. England has lagged behind, but a beginning at least has been made in Cambridge. The present is a bad time to propose any extension of university teaching or expenditure, but it is to be hoped that the endowment of research will be carried on by the liberality of individuals, if not by our heavily burdened Governments; and we may claim for such a purpose the goodwill of all who desire to see the facts of mental science affiliated with those of physics and physiology.

Yet another recent development of mental science remains to be mentioned. Psychology may fairly include the whole of the phenomena of intelligence displayed throughout the animal kingdom. As there is a study of comparative anatomy in which the structures of different organisms are compared, and a study of comparative physiology in which organic functions are compared, so there is a legitimate study of comparative or animal psychology in which the sensibilities and intelligence of the lower animals are compared among themselves and with those of man. The inquiry has its peculiar difficulties; for it the intelligence of our fellow-men is known to us only by inference, it is by a more remote analogy that we pass from the actions of the lower animals to the measure of their intelligence. Still, we must not underrate its

importance on this account, and it has received a powerful stimulus from its connection with the theory of evolution. If, it is argued, there is reason to believe that all animals are descended from the same primitive forms, is it not reasonable to believe that the intelligence associated with these organisms has similarly developed? On this hypothesis the problem of evolutionary psychology is to show how, in accordance with the known or inferred facts of animal intelligence, the supposed development may have taken place. The theory which presents itself for verification offers, at the same time, a powerful stimulus to the investigation of facts. Much has been done in collecting, verifying, and arranging facts in a graduated series; and progress has been made also in obtaining a criterion by which the first beginnings of animal intelligence may be tested, and in fixing the intellectual limits which sever the lower animals from man. Wherever we find the power of making new adjustments or modifying old ones as a result of individual experience, there we may infer with very great probability the presence of intelligence. Ascending in the scale, we must admit that our humbler brethren are capable of perception, memory, and imagination. They exhibit curiosity also, paying attention to characteristics which interest them; and we cannot deny them the power of reasoning, since they form expectations on the strength of past experience. At the same time it would appear that their reasoning is always about concrete facts. There is no evidence that they can, like man, form abstract ideas in which attributes are regarded in isolation from concrete things, or that they can reason abstractly, or are capable of reflective self-consciousness. I need scarcely add that in this region many questions remain unsolved, and there is much which is open to dispute.

While, as I have said, it is the tendency of modern Science to investigate these departments of psychology in abstraction from the ultimate problems of philosophy, it is not to be understood that the task of isolation is an easy one. I have not yet met with any work on psychology which did not betray, more or less distinctly, the philosophical tenets of its author. Philosophy is more closely related to psychology than to the sciences which are occupied with the material world. The physicist has no difficulty in considering the world of matter and motion in abstraction from the mind which knows it. If he seeks to examine thoroughly the conceptions which he is constantly using, and begins to inquire into the nature of causation, of matter, and of force, he has left the physical sphere, and has entered the metaphysical. But, as a physicist, he is under no temptation to make the transition. With the psychologist it is otherwise. At almost every point he is in danger of crossing the dividing line. He must take for granted, to begin with, the existence of mind. It is easy to say that he should occupy himself with the facts or phenomena of mind. But what are the facts? If it be

meant that he is to attend only to sensations and ideas, or other states of consciousness, without ascribing them to a mind whose states they are, then we may reply, with Lotze, that this "involves a wilful departure from what is actually given in experience," since a mere sensation or idea "without a subject is nowhere to be met with as a fact." And if we speak of phenomena, do we not imply some reality of which we know the phenomena or appearances? Here, then, we find ourselves encompassed by metaphysical questions. While psychology has been sometimes used to assist the doctrine of a transcendent *ego*, it has been used equally in the interests of an atomistic philosophy—as when Hume descended into his own consciousness, with the result that he never caught himself without a perception, and never succeeded in finding anything more. If in mental science we are to maintain the strictly scientific point of view, the only cure for such controversies is to state at the outset the assumptions which we make. It seems to me that it would be enough for psychology to begin with that common-sense assumption of the self, or I, which is conveyed in ordinary language, leaving it to metaphysics to decide what is the precise meaning to be given to this conception. There cannot be a doubt that there is some bond of connection between our successive states of consciousness. Even in the strange cases of double personality the facts of each phase are in some way bound together. Take, for example, the oft-quoted case of Félicité X., who alternated between her natural condition, in which she was serious and reserved, and a condition of restless gaiety. The events of each condition were knit together as belonging to the experience of the same person; and there was a connection also between the two, since during the second condition the occurrences of the first were remembered. But after psychology has said its last word about memory, or customary feelings, or anything else, as elucidating the connection of our states of consciousness, the meaning of personality remains for the treatment of philosophy. On the other hand, the psychologist is at liberty, if he thinks it will do him any good, to begin with the hypothesis that states of consciousness are separate existences. But even if such a hypothesis could endure the test of comparison with the mental facts, it, too, would need to be referred to the criticism of philosophy. Another instance of the temptation to pass lightly from psychology to metaphysics may be found in the attitude of the psychologist towards the material world. He begins by adopting the dualism of ordinary thought, which supposes the objects which we perceive in space to be altogether different from the percipient mind. But his treatment as a psychologist limits him to impressions and ideas, sensations and percepts; he nowhere comes into contact with the independent material world which he postulated. What, then, can be more natural than that his thought should turn back on itself, and that he should ask if the material world may not be resolved

into complexes of sensations and their possibilities? Thus an intelligent student, after the perusal of such a textbook as Sully's "Outline of Psychology," may imagine that there is no escape from a doctrine of subjective idealism. But here, again, as Sully is careful to point out, a distinction must be made between the psychology and the philosophy of perception. The "individualistic" conclusion is the result of the limitation of our inquiry to mental facts; and we are not to take a restriction which we have ourselves deliberately made as the ultimate limit of our knowledge. In this case also psychology must stand aside, and make way for the final criticism of philosophy. Even physiological psychology, while it clings to the phenomenal dualism between mind and matter, is not free from the temptation of making certain presuppositions of its own the basis of a metaphysic. It begins by postulating an exact correspondence between physiological and psychical facts, the latter depending on the former as their conditions. Here is an hypothesis which may be fairly worked, as Professor James puts it, "for all it is worth;" we need not exclude working hypotheses in psychology any more than in other positive sciences. But the psycho-physiologist may proceed to ignore, or to deny, mental facts for which he is unable to find any physiological counterpart; and thus in psychology he may give us a revised edition of the old theory of transformed sensations, and may also use his psychology as the basis of a philosophical theory of materialism or automatism. Such a use of his own presuppositions is clearly illegitimate.* Facts which consciousness attests do not depend for their reality on the success of an explorer in the field of cerebral physiology, and the enunciation of a hypothesis at the outset of an inquiry does not prove its truth. Any results which may be reached in following out such a hypothesis are subject to the verification of facts, and, finally, to philosophical investigation into the ultimate nature of matter and of mind.

(Of the methods to be employed in philosophy, as thus distinguished from psychology, time would fail me to speak. Strictly, philosophy should not be included under mental science; but we may, I think, taking a liberal interpretation, gladly welcome any philosophical contribution which is the outcome of genuine thought. The unreasonableness of attempting to exclude all consideration of the questions of philosophy is shown by its futility. How is it possible that the human mind, encouraged by the spirit of modern Science to push its inquiries to the uttermost, should stop short abruptly, declining all investigation into the first principles or conditions of knowledge and of being? Every polemic against metaphysics is itself a metaphysic in disguise, for an assertion of the impossibility of answering metaphysical

* The danger here briefly touched upon has been fully treated, with reference to recent speculations, by Dr. Ward, in an article entitled "Modern Psychology: a Reflection," in *Mind* for January, 1893, and by Professor Seth in an article on "The New Psychology and Automatism," in the *Contemporary Review* for April, 1893.

questions implies, if it be made with any show of reason, that these questions have been faced; and experience proves that philosophy, if denied admittance at the door, will come in at the windows, and will make itself heard, if in no other way, in the ostensible utterances of physics and physiology.

I cannot conclude without referring, however briefly, to logic, ethics, and æsthetics, as sciences at once theoretical and practical, drawing their materials to a large extent from mental science while connected with philosophy in their fundamental principles. In æsthetics little has been done of recent years beyond assimilating more thoroughly the results attained by Continental thinkers. There are, I think, influences now at work in Australasia which prophesy a deeper interest than has hitherto been taken among us in the philosophy and history of art. The aspect of logical science has been completely changed within the present century. It was remarked by Kant, that since the time of Aristotle logic had not retraced a single step, nor had it been able to take one step in advance. But now it must be confessed by the firmest adherents of the traditional logic, that even formal logic has undergone some changes, and has added to its territory a symbolic logic which was little more than hinted at before. So powerful, indeed, are the methods of symbolic logic, even in its simplest forms, that its analysis goes far beyond the needs of ordinary reasoning, and logicians are compelled to manufacture complicated arguments to illustrate its strength. In inductive logic we have a study which, though foreshadowed by Bacon, is peculiarly the product of our century, which follows closely the procedure of scientific thought, and was impossible till Science had achieved its modern triumphs. The indebtedness of inductive logic to Whewell, Herschel, and Mill cannot be forgotten; but in Great Britain and her dependencies we have suffered, perhaps, by too great a deference to the authority of Mill, and we owe to Germany the best work which has recently been done in this branch of study. In ethics and moral philosophy a great change is now in progress. The individualistic view of man which has been prominent in English thought is now being supplemented, under various influences, by that older view which represents man as essentially a social being, a member of a social organism, fulfilling his own life most fully in living for others as well as for himself. The two great schools of moral philosophy—one seeking to resolve morality into simpler elements, the other denying that it can be so resolved—still remain; but both have been profoundly influenced by the thought of evolution, a conception, indeed, which was freely applied to the development of morality before it found its way into natural science. The older empirical doctrine, that morality has its origin within the lifetime of the individual from egoistic or social impulses, is dying out, and is replaced by the doctrine that the moral intuitions and sentiments are the results of ages of evolution. The “long results

of time" in the moral education of mankind are equally acknowledged by philosophers of the opposite school; and it is for them to reconcile their faith in morality as part of the constitution of man with the general theory of evolution, and to show how the growth of the principle of duty in the lives and institutions of men is compatible with the denial of an empirical origin of morals.

The sketch which I have offered you of the present position of mental science is necessarily imperfect. Many topics might have been dealt with in greater detail; but this could have been done only at the cost of laying a greater burden on your patience, which has already, I fear, been too heavily taxed. I have aimed at showing that mental science in every one of its branches has been no exception to the law of progress. If I have succeeded here I shall be satisfied, for progress in the past must inspire hope for the future. To me it seems not only likely, but inevitable, that increasing attention will be paid to mental science. The child, drawn out of himself by the sights and sounds which solicit the senses, acquires a knowledge of surrounding objects and persons before he gains a distinct idea of himself; and so the human mind, enriched by its triumphs in physics, in chemistry, and in biology, must return upon itself, feeling that the circle of its knowledge is incomplete till the secrets of mind as well as of the material universe have been thoroughly explored.

REPORT OF SEISMOLOGICAL COMMITTEE.

Members of Committee.

MR. A. B. BIGGS	CAPTAIN SHORTT
MR. R. J. L. ELLERY	SIR C. TODD
SIR JAMES HECTOR	MR. G. HOGBEN
MR. H. C. RUSSELL	(Secretary).

With the exception of the earthquake of January 27th, 1892, which was felt throughout Tasmania and in the south-east of Australia, and one or two slight shocks in Tasmania, recorded by Mr. A. B. Biggs, earthquake activity in Australasia during 1892 was confined to New Zealand. In the last-named colony there were seventy-one shocks, of the usual mild description. For the recording of these we have again to thank Dr. Lemon, Superintendent of Posts and Telegraphs, Wellington, for his kindness in allowing memoranda to be forwarded by the officers of his department. We are also indebted to several private observers, chief among whom must be mentioned Mr. H. C. Field, of Wanganui, who regularly supplied careful notes of all shocks observed by him.

The Tasmanian earthquake of January, 1892, has been the subject of an investigation by Mr. G. Hogben. He assigns to it an origin situated east of Tasmania, the epicentric area being a narrow strip lying between $153^{\circ} 56'$ and $154^{\circ} 36'$ east longitude, and between $41^{\circ} 13'$ and $40^{\circ} 46'$ south latitude, and situate at its nearest point 353 miles from Launceston and 365 miles from Hobart. The maximum intensity was between VII. and VIII. on the Rossi-Forrel scale; the velocity of propagation about twenty-six miles per minute. The epicentrum is not far from that found by the same writer for the earthquake of the 13th May, 1885, and it would probably be safe to conclude that all the chief shocks of the remarkable series of earth disturbances that took place in Tasmania and South-East Australia from April, 1883, to December, 1886, proceeded from the same region, and possibly that the

smaller and more isolated shocks were secondary earthquakes, whose primary source was also situated there.

The late Captain Shortt was good enough to place in the hands of the Secretary of this Committee his full and interesting records of Tasmanian earthquakes (1883-6); but to include all these—there were 2,540 shocks—in the present report would extend it to too great a length. The records have been collated and reduced by the Secretary, and any one who wishes to consult them for the purpose of scientific work may apply to him.

The chief details of the most important shocks have been already published in papers, read by the late Captain Shortt and Mr. A. B. Biggs before the Royal Society of Tasmania.

In New Zealand the earthquake of December 4th, 1891, alluded to in our last report, was dealt with in a paper by Mr. George Hogben, M.A. (see *Transactions N.Z. Inst.* 1892, p. 362). During the present year (February 12th, 1893) Nelson has been visited by perhaps the most considerable earthquake since 1855, which threw down a large number of chimneys, but did not do much other damage. The epicentrum was not far from the town of Nelson. The velocity of propagation was much greater than is usual with New Zealand earthquakes, forty-nine or fifty miles per minute (paper read before the Philosophical Institute of Canterbury by G. Hogben, July, 1893).

The Committee has begun correspondence with observers in various parts of the Pacific. It is, however, too early yet to expect many definite results. The Rev. W. Gray, of Tanna, New Hebrides, has kindly forwarded, through Mr. H. C. Russell, notes of earthquakes since 1887, and now (since March, 1892) is making regular observations in the manner recommended by this Committee. A table appended to the report contains the chief details of Mr. Gray's observations. The following notes will perhaps serve to make the table more useful:—There are three active volcanoes in the New Hebrides—one on Tanna, another on Ambrim, and a third on Lopevi; that on Tanna has the largest crater, is 600ft. high, and is distant five or six miles from Weasisi, where Mr. Gray lives. Volcanic action is almost exactly in the line of the group of islands, and the volcanoes and volcanic springs of this group and Banks' Islands (next to the north) are nearly in one line. This line has the largest islands on either side, and extends 600 miles (Steel's "New Hebrides" and Markham's "Rosario," as quoted therein).

We find the following notices of previous earthquakes:—

August, 1868.—Tidal wave from east (observed also in New Zealand) at Port Resolution, Tanna ("New Hebrides," Inglis, p. 184).

March 28th, 1875, 11.15 p.m.—Heavy earthquake and tidal wave on Aneityum (south of Tanna), followed by three other shocks. Intensity of greatest probably VIII. to IX. on the Rossi-

Forel scale. Earthquake and wave also felt on Aniwa and Eromanga, and the tidal wave most severely felt at Lifu, on the Loyalty Islands.*

May 5th, 1875, 2 a.m.—Very heavy earthquake in Aneityum, intensity IX., followed by frequent slighter shocks for three months ("New Hebrides," Inglis, p. 194).

January 10th, 1878.—Great earthquake at Port Resolution, Tanna; "two minutes after the earthquake a rise of the land on the whole west side of the harbor took place, to the extent of about twenty (20) feet" (Steel's "New Hebrides," p. 189).

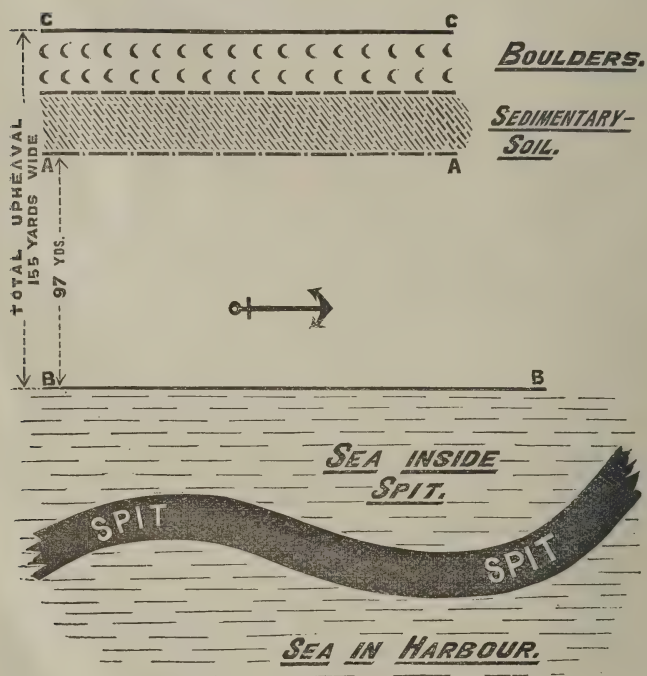
February 14th, 1878.—Another earthquake "caused a further elevation of the western side of about twelve (12) feet. Rocks which were formerly covered with seven or eight fathoms of water are now above high-watermark" (*ibid*).

Darwin alludes, it may be remembered, to the recent elevation of these islands ("Coral Islands," chap. VI., p. 100, Minerva Lib. Edn.).

In this connection a portion of a letter from Mr. Gray, dated January 27th, 1890, contains a record of such a striking instance of rapid and permanent elevation of land, that it deserves to be quoted in its entirety:—"In the early part of 1888, while we were absent, earthquakes were very severe and frequent. In April and June upheavals took place in Port Resolution harbor, so that since 1868 (? 1878) there have been three upheavals at this same spot. . . . The upheaval in 1868 was instantaneous and to the height of fully 20ft. The opposite side of the harbor was not affected. It was followed by an enormous tidal wave, and a part of the harbor where ships used to anchor was left high and dry. On April 20th, 1888, a similar upheaval took place, but did not extend so far along the coast. On examining this part I walked over ground dryshod, where, about a year before, I sailed in a boat, and at one time there was 30ft. of water. There is a perpendicular cliff (cc, as shown in diagram on page 210), then boulders for 31yds., next 27yds. of sedimentary soil in layers at regular intervals, following the same curve as the cliff, and with a slight dip seawards from the cliff to line AA. This distance (cc to AA, 58yds.) shows the width of land lifted out of the sea on April 20th; between the next two lines (AA and BB) the upheaval of June 24th, 97yds. in width; total width, 155yds. ➔ shows the spot where our mission vessel lost an anchor more than ten years ago. It was brought up now. . . . These upheavals occurred at the time earthquakes were so violent on Tanna."

* It might be interesting to know whether the earthquake shock as well as the tidal wave was observed at Lifu, or whether other earthquakes, originating, as this probably did, beneath the plateau on which the New Hebrides stand, have been felt in the Loyalty Islands or in New Caledonia, which are separated from the New Hebrides by a narrow but deep depression in the ocean bed. If so, the evidence would suggest a general movement of this part of the Pacific bed, or at least a fairly deep extension of the centrum of the earthquakes. We must wait, however, till we get returns from the Loyalty Islands and New Caledonia (Sec. Seism. Comm.).

Diagram referred to on page 209.



Appendix I.

EARTHQUAKE SHOCKS IN NEW ZEALAND, 1892.

* Time verified. A = A.M. P = P.M.

Date.	Place.	Time (N.Z. Mean Time).	Apparent Direction.	Apparent Duration.	Effects—Remarks.	Intensity (Rossi-Forel Scale).
1892.						
Jan. 1	Wellington	12-20 A*	—	—	A quiver	II.
" 1	Opunake	12-21 A*	E. to W. then S. to N.	12 secs.	Pictures moved; loud rumbling accompanying	IV.
" 2	Wanganui	2-54 A	S.W.	A few secs.	Sharp blow; faint rumble preceded and accompanied shock ..	III.
" 6	"	5-39 A	S.W. to N.E.	Rather more than 1 sec.	Slight	III.
" 11	Dunedin	3-20 P*	N.E. to S.W.	About 5 secs.	Slight	III.
" 11	"	3-22½	—	34 secs.	Furniture shaken ..	IV.
" 11	Invercargill	3-20 P*	W. to E.	30-40 secs.	Sharp; clocks stopped; glass broken	VI. to VII.
" 11	Queenstown	3-20 P*	N.W. to S.E.	20 secs.	Severe; clock facing E.S.E. stopped	IV.
" 11	Riverton	3-20 P*	S.E. to N.W.	10-15 secs.	Severe; clocks stopped and started	V. to VI.
" 11	Otautau	3-20 P*	"	20 secs.	Clocks stopped; severe ..	V. to VI.
" 11	Gore	About 3-20 P	—	25 secs.	Plaster cracked ..	say VI.
" 11	Mataura	10-43 P*	S.W. to N.E.	About 15 secs.	Distinctly felt ..	V.?
" 11	Arrowtown				Three shocks heavy ..	V.?
" 11	Wanganui				Very slight; dull report; rumbling before and during shock ..	III.
" 12	"	10-8 P	—	A few secs.	Accompanied by faint rumble	II.
" 12	"	10-17 P	—	A few secs.	Slight shock, followed by sharp one; window sashes rattled;	IV.
" 22	"	9-49 A*	S.W. to N.E. (or between that and S. to N.)	30 secs. in all	faint explosion before. On Wednesday, January 20, Ngauruhoe was discharging unusual smoke	
" 22	"	9-48 A*	N.E. to S.W.	40 secs.	Sharp; causing doors to swing ..	IV. +

Earthquake Shocks in New Zealand, 1892—continued.

Date.	Place.	Time. (N.Z. Mean Time.)	Apparent Direction.	Apparent Duration.	Effects—Remarks.	Intensity (Rossi-Forel Scale).
1892.						
Jan. 22	Bulls	9.46 A	N.W.	2 secs.	Sharp	III.
" 22	Wanganui	9.16 P*	Indefinite	About 1 min.	Very slight, with loud rumbling accompanying	II. to III.
" 22	"	10.11 P*	S.W. to N.E. (rather more southerly than usual)	About 40 secs.	Sharp; slight rattling of window sashes; another slight shock about 11 p.m.	III. to IV.
" 25	Timaru	8.36 or 8.36½ A	N.E. to S.W.	2 or 3 secs.	Slightly shook movable objects; sound of explosion from N.E. heard before	III. to IV.
" 30	Wanganui	2.10 P	S.W. to N.E.	2 secs.	Sharp; sharp jolts and half-dozen vibrations	III. +
" 30	"	9.30 P	"	About 1 min.	Slight	III.
Feb. 9	Gisborne	4.32' 30" A*	N.E. to S.W.	3-6 secs.	Severe	III. to IV.
" 9	Wanganui	4.45 A	"	—	"	—
" 9	Napier	4.43 A*	N.W. to S.E.	3 secs.	Sharp; clocks stopped	V. to VI.
" 10	Rotorua	11.45 P*	—	2 secs.	Slight; a little rumbling	III.
" 14	Waikanae (30 miles north of Wellington)	11.19 P	S.W. or S.S.W.	Main shock 10 secs.; total 30 secs.	Rather loud rumbling; sharp jerk, followed by shake	III. to IV.
" 14	Wellington	11.20 P }	—	—	Newspaper	—
" 14	Wellington	11.25 P }	—	—	Sharp, preceded by rumbling	III. +
" 14	Marton	11.30 P }	—	—	Slight	III.
" 14	Woodville	11.22 P }	N. to S.	Very short	Slight jolt followed half dozen slight vibrations; slight noise	III.
" 14	Palmerston	6.10 P*	"	2 secs.	Three shocks, vertical; slight rumbling accompanied shock	III.
Mar. 2	Queenstown	3.13 P	From S.W.	1 sec.	Very gentle vibration; no noise	III.
" 10	Wanganui					III
" 12	"	About 11.30 P	S.W. to N.E.	Nearly 1 min.		
" 20†	"	10.13 P	"	A second or so		

April	1	Location	Time	Direction	Duration	Description	Intensity
"	"	Marton	8-14 P*	W. to E.	5 secs.	Slight	III.
"	"	Wanganui	8-14 P*	N.E. to S.W.	2-5 secs.	Sharp ; loud rumbling like thunder	III.
"	"	"	—	S.W. to N.E.	About 1 min.	Faint rumbling, then gentle vibration	III.
"	"	"	About midnight (11 to 12 April)	"	—	No noise ; sharp jerk ; houses and furniture shaken	IV.
May	7	Riverton	5-55 P*	"	15 secs.	Sharp	III. +
June	2	Rangiora	12-55 to 12-56 P	W. to E. (?)	$\frac{1}{2}$ sec.	Slight	III.
"	"	Wanganui	10-14 to 11 P	S.W. to N.E.	—	Nine shocks ; no noise	III. —
"	"	"	9-43 P	"	—	Slight rumbling, then sharp shock	III.
"	"	Opunake	3-3-30 A	E. to W.	About 2 secs.	Slight rumbling sound	III.
July	2	Queensdown	7-29 $\frac{1}{2}$ P*	N.E. to S.W.	4 secs.	Slight rumbling	III.
"	"	Gore	7-30 P	—	—	—	—
"	"	Fortrose	7-40 P	—	—	Newspaper	III.
"	"	Napier	7-15 A	N. to S.	15 secs.	Severe	IV.
"	"	Wanganui	7-15 A	S.W. to N.E.	1 sec.	Very slight	III.
"	"	"	8-13 A	"	1 sec. +	Very sharp ; violent upheaval	IV. +
"	"	"	7-26 P	W.S.W. to E.N.E.	"	Sharp jerk ; subterranean rumbling	III.
"	"	Blenheim	7-7 A	S. to N.	8 secs.	Slight ; previous tremors	III.
"	"	Wanganui	6-53 P*	N.E. to S.W.	2-5 secs.	Smart	III.
"	"	Timaru	About 3-57 A	—	—	About three short shakes	II.
"	"	Wanganui	8-25 P*	N.W. to S.E.	3-4 secs.	Sharp jerk followed by sharper one, slight rumbling accompanying	III.
"	"	"	2-32 A	S.W. to N.E.	1 sec. +	Dull explosion, followed by jerk and vibration	III.
"	"	"	10-42 P	"	2 or 3 secs.	No noise ; windows rattled	III. +
Aug.	2	"	10-8 P	"	$\frac{1}{2}$ min	Very slight ; no noise ; windows rattled a little	III.
"	"	"	10-45 P	"	About $\frac{1}{2}$ min.	Faint explosion ; two or three secs. after vibration and rumbling	III.
"	"	"	1-58 A*	N.E. and S.W.	6 secs. (or 1 min., ?)	Loud explosion ; underground sharp vibrations	IV.

* N.B.—Ngauruhoe active.

† N.B.—Ngauruhoe continues active ; a photo. of hot lake at Ruapehu shows it much higher than ten years ago (Mr. Field).
 ‡ Eruptions of Etna and Sanguer.

Earthquake Shocks in New Zealand, 1892—continued.

Date.	Place.	Time. (N.Z. Mean Time.)	Apparent Direction.	Apparent Duration.	Effects—Remarks.	Intensity (Rossi-Forel Scale).
1892. Aug. 14	Marton	About 2 A	N.E. to S.W.	8-10 secs.	Sharp; caused articles to rattle; preceded by roar; woke most people	V.
" 22	Waotu	4.35 A*	S.W. to N.W. (?)	20 secs.	Slight	III.
" 23	"	5.15 A*	"	15 secs.	Slight	III.
" 23	Dunedin	A few minutes after 6 A	—	—	Slight	II.
" 23	Wanganui	3.24 P	S.W. to N.E.	About $\frac{1}{2}$ min.	Slight; jerk followed by vibrations; slight explosion before	III.
" 24	Collingwood	8.2 A*	N.E. and S.W.	1 min.	Slight shock, followed immediately by sharp one	III. +
" 24	Westport	8.3 A*	S.E.	1 sec.	Severe	III. +
" 24	Hokitika	8.5 A*	N.-S. or N.E. to S.E.	10 secs.	Slight; crockery shaken; boat on lake seemed to be striking ground, but was in deep water ..	V.
" 24	Nelson	8.3 A*	S. to N.	About 10 secs.	Sharp; articles on books swung; rumbling before and after	IV.
" 24	Wanganui	8.4	S.W. to N.E.	Few secs.	Slight; no noise	III.
" 24	Picton	8.2*	S.S.E. to N.N.W.	About 10 secs.	Sharp; rumbling followed by rattling of crockery, windows, houses	IV. +
" 24	Opunake	8.7	S.E. to N.W.	3 secs.	Sharp; building rattled, doors creaked; rumbling ..	III. to IV.
" 24	Christchurch	8.5 A*	N.W. to S.E.	About 3 secs.	Slight	III.
" 24	Blenheim	8.3 $\frac{1}{2}$ A*	S.E. to N.W.	10-15 secs.	Sharp; clocks stopped ..	VI.
" 24	Rangiora	8.2 A*	E. to W.	1 $\frac{1}{2}$ secs.	Slight; house creaked slightly ..	III. to IV.
" 24	Wellington	8.3 A	S.E. to N.W.	15 secs.	Moderate; a very long tremor ..	III. +
" 24	Greymouth	8.9 A*	N.E. to S.W. and N. to S.	8 secs.	Sharp; made crockery rattle and pictures oscillate; rumbling sound ..	IV. +

"	25	Wanganui	About 4 A	—	—	Very slight tremors; slight rumbling	II.
"	25	"	9-28 P	—	$\frac{1}{2}$ min.	Very slight; low rumble	II.-III.
"	26	"	10-13 A	S.W. to N.E.	Nearly 1 min.	Sharp blow; produced hum in telegraph pole	III.
Sept.	7	"	9-52 P	—	$\frac{1}{2}$ min.	Slight	III.
"	7	"	10-48 P	—	Nearly 1 min.	Slight	III.-II.
"	11	"	8-20 P	S.W. to N.E.	About $\frac{1}{2}$ min.	Slight; vibrations accompanied by rumbling	III.-II.
"	13	Timaru	12-48 A	N.W. to S.E.	—	Heavy and prolonged; felt by compositors standing in printing office; crockery rattled; sleeper awakened	IV.-V.
"	13	Cromwell	12-40 A*	N. to S.	A few secs.	Slight; preceded by rumbling	III.
"	13	Queenstown	1-20 A*	W. to E.	5 secs.	Sharp; rumbling	III. +
"	15	"	9-15 A*	E. to W.	2 secs.	Slight	III.
"	19	"	3-46 P	N. to S.	3 secs.	Slight; slow wavy motion	III.
Oct.	8	"	11-10 $\frac{1}{2}$ P*	"	20 secs.	Severe; crockery thrown off shelves; bottles broken; double shock	VII.
"	8	Riverton	11-11 P*	E. to W.	"	Sharp; preceded by rumbling; pictures sway	V.
"	8	Dunedin	11-10	W. to E. (?)	2 secs. and 5 secs.	Rather sharp; clocks stopped; crockery rattled; two shocks	V.-VI.
"	8	Timaru	11-13*	E. to W.	3-5 secs.	Sharp	IV.
"	11	Wanganui	1-58 P*	N.E. to S.W.	6 secs.	Sharp; slight rumbling	III. +
"	11	Herbertville	1-57 P*	S. to N.	20 secs.	Sharp; crockery broken; chimneys cracked	VII.
"	11	Napier	1-58 P*	—	2 secs.	Sharp	III.
"	11	Fielding	1-57 P*	E. to W.	30 secs.	Sharp	III. to IV.
"	11	Woodville	1-58 P*	"	1 min.	Sharp; followed by lighter shock; pendulum clocks stopped at watch-maker's; preceded by rumble	VI.
"	13	Wanganui	1-30 P	—	—	Horizontal shock	III.
"	13	"	6-43 P*	N. and S.	Short	Horizontal shock; slight	III.
"	13	"	10-15 P	—	—	Shock from below	H.

Earthquake Shocks in New Zealand, 1892—continued.

Date.	Place.	Time. (N.Z. Mean Time.)	Apparent Direction.	Apparent Duration.	Effects—Remarks.	Intensity (Rossi-Forel Scale).
1892.						
Oct. 17	Wanganui	4.20 P	S.W. to N.E.	Over $\frac{1}{2}$ min.	Moderate vibrations.	III.
Nov. 6	"	8 A	—	—	Rather sharp	Say III.
" 9	"	11 A	—	—	Very slight	Say II.
Dec. 1	Gisborne	6.58 A*	E. to W.	10-12 secs.	Sharp; knocked bottle off shelf	VI. to VII.
" 1	Waipuo Bay	2 A	—	—	—	III.
" 1	"	4.30	—	—	—	III.
" 1	"	7 A†	—	—	—	IV.
" 1	"	7.8 A	—	—	—	III.
" 1	"	9.40 A†	—	—	—	IV.
" 1	"	10.55 A†	—	—	—	VII.
" 1	"	11.56 A	—	—	—	III.
" 3	Wanganui	7.36 A*	N. to S. or S.W. to N.E.	6 secs.	Broke all bottles in one of hotels.	III.
" 3	"	7.56 P*	S.W. to N.E.	6-12 secs.	Sharp; loud rumbling	II.
" 4	"	6.12 P	"	Several secs.	Very slight; rumbling before	III.
" 6	"	11.59 A	"	10 secs.	Low rumbling; slight vibration.	III.
" 26	Christchurch	6.45 A	N. to S.	About 5 secs.	Loud explosion and heavy rumbling	IV.
" 26	Rangiora	6.43 A*	W. to E.	6 or 7 secs.	Sharp; windows rattled; preceded by rumbling	III.
" 26	Timaru	6.45 A*	N.N.E. to S.S.W. or N. to S.	5 to 7 secs.	Slight; several distinct vibrations. Sharp; bed shaken; windows, &c., rattled; woke sleepers upstairs; maximum of noise before shock	V. or VI.
" 26	Ashburton	6.48 A	N.E. to S.W.	5 secs.	Sharp	III.
" 26	Hokitika	6.45 A*	"	About 5 secs.	Sharp	III.

† Gisborne also.

* Gisborne, also at Port Awarua.

Appendix II.

EARTHQUAKE SHOCKS AT WEASISI, TANNA, NEW HEBRIDES, 1887-1892.

Reported by Rev. W. Gray.

A = A.M. P = P.M.

Date.	Place.	Time (Local).	Apparent Direction.	Apparent Duration.	Effects—Remarks.	Intensity (Rossi-Foré Scale).
1887.						
Jan. 18	Weasisi (Island of Tanna)	5.50 A	—	—	Twenty-six volcanic eruptions during the month	—
Feb. 4	"	8.0 A	—	—	One shock	—
" 5	"	—	—	—	Two shocks } Twelve volcanic eruptions	—
" 7	"	—	—	—	One shock	—
" 24	"	—	—	—	One shock	—
Mar. 14	"	2.0 P	—	—	Thirty-four volcanic eruptions.	—
" 30	"	4.0 A	—	—	Volcano very active on 28th ..	—
April 5	"	10.0 P	—	—	} Thirty-three eruptions ..	—
" 11	"	9.0 A	—	—		—
" 11	"	6.0 P	—	—		—
" 16	"	12 noon	—	—	} Nine shocks } Twelve erup- Three shocks tions	—
" 25	"	10.0 A	—	—		—
May 6	"	A.M.	—	—		—
" 9	"	—	—	—	Two shocks	—
" 30	"	—	—	—	Fifteen eruptions ..	—
June 2	"	9.0 P	—	—	No earthquake shocks. Eight vol- canic eruptions	—
July	"	—	—	—	Twelve shocks } Twenty-seven One shock volcanic erup- tions	—
Aug. 5	"	10.0 A	—	—		—
" 22	"	4.0 A	—	—		

Earthquake Shocks at Weasisi, Tanna, New Hebrides, 1887-1892—continued.

Date.	Place.	Time (Local).	Apparent Direction.	Apparent Duration.	Effects—Remarks.	Intensity (Rossi-Forel Scale).
1887. Sept. 4	Weasisi (Island of Tanna)	—	—	—	No earthquakes or eruptions	—
“ 27	“	9-30 P	—	—	One shock	—
“ 30	“	2-0 A	—	—	One shock	—
Nov. 7	“	9-30 P	—	—	One shock	—
“ 30*	“	10-0 A	—	—	} Eighty-seven volcanic eruptions } during month	—
1888. Dec. 1	“	4-40 A	—	—	Severe long rough shock.. ..	V.-VI. †
“ 18	“	8-50 A	—	—	Triple shock. Volcano very active on 8th: heavy fall of volcanic dust, 13th	—
1889. Jan. 5	“	—	—	—	One shock. Heavy fall of vol- canic dust on 11th	—
Feb. 2, 7, 13, 16, 19, 25, 26, 27	“	—	—	—	Sixteen shocks; 26th, severe. Heavy fall of volcanic dust on 19th	V.
Mar. 6, 7, 9, 23, 31	“	—	—	—	Six shocks. Fall of volcanic dust on 29th	—
April 9, 26, 27, 28, 29, 30	“	—	—	—	Nine shocks; 26th severe. Heavy fall of volcanic dust on 29th	V.

May 17, 20	"	—	—	—	Two shocks	..	..	—
June 2, 7, 14, †	"	—	—	—	Three shocks; 7th, severe	..	..	V.
Aug. 12	"	—	—	—	Slight shock	..	..	II.-III.
Sept. 1, 29	"	—	—	—	Two shocks	..	..	—
Oct. 10, 13, 28	"	—	—	—	Three shocks. Volcano heard occasionally at end of month	..	..	—
Nov. 2, 18, 27	"	—	—	—	Three shocks. Volcanic dust from S.S.E. on 24th	..	..	—
Dec. 9, 16	"	—	—	—	Two shocks. 8th, cloud of volcanic dust, but not from Tanna volcano	..	..	—
1890 § Jan. 11	"	6.30 A	—	—	Slight. Falls of volcanic dust 1st, 2nd, 8th to 11th, 14th to 18th, 22nd	..	..	II.-III.
Feb. 8	"	—	—	—	Double shock, without interval; each gradually increased, then died away	..	..	—
" 16	"	—	—	—	Short slight shock. Volcanic eruptions 12th, 13th, 18th, 19th, 24th, 26th, 28th; falls of volcanic dust 4th, 6th, 9th, 12th to 14th, 16th-18th, 23rd-28th	..	..	II.

* November, 1887, to December, 1888, Mr. Gray was on visit to England, hence no observations.

+ Before 1892 the estimate of intensity can only be taken as rough.

‡ June 18th to 25th, Mr. Gray from home; no observations.

§ Extract from letter of Mr. Gray's, January 27th, 1890 :—" Since the beginning of 1889 the volcano has been much less active, and since May, 1889, the activity has been so slight as scarcely to indicate the presence of a volcano (which is about five or six miles distant). Earthquake shocks have also been diminishing in frequency, force, and duration; a shock is a rare thing now, and always faint."

Earthquake Shocks at Weasisi, Tanna, New Hebrides, 1887-1892—continued.

Date.	Place.	Time (Local).	Apparent Direction.	Apparent Duration.	Effects—Remarks.	Intensity (Rossi-Forel Scale).
1890. Mar. 16	Weasisi (Island of Tanna)	5.45 P	—	—	Long slight shock, fine trembling motion. Volcanic eruptions 1st, 2nd, 12th, 13th, 22nd-24th, 27th; dust 2nd, 13th, 14th, 20th-23rd, 30th, 31st	III.
April 17	"	10.40 P	—	—	Prolonged; moderately severe. Eruption 12th; dust 2nd, 4th, 5th, 12th, 13th, 18th, 20th, 22nd, 23rd. Compared with previous years activity of volcano not more than $\frac{1}{4}$	IV.
May 26	"	8.45 P	—	—	Severe slow prolonged motion, circular (right to left)	IV.-V.
" 27	"	9.0 A	—	—	Slight; did not move lamps	III.
" 28	"	9.0 A	—	—	Sharp	V.
July 26	"	—	—	—	* Severe. Eruptions 4th, 15th, 17th June; dust 14th, 15th June, 21st-26th July	—
Aug. 7	"	—	—	—	Severe } Two eruptions; dust	} IV. to V.
" 19	"	—	—	—	Severe } seven days in month	
" 24	"	—	—	—	—	} —
Sept. 5	"	5.15 A	—	—	Two eruptions, 4th, 7th. Dust	
" 8	"	4.0 A	—	—	1st, 4th, 6th, 7th, 12th	} —
" 21	"	8.20 P	From S.W. (?)	—	Slight } Dust on 9th, 19th, 20th,	
Oct. 5	"	8.30 P	—	—	Severe } 28th	} II.-III. IV.-V.
" 7	"	8.0 P	—	—	—	
" 29	"	4.20 P	—	—	—	—

[illegible]

* No daily observations after June 18th, or from July 27th to August 10th.

Earthquake Shocks at Weasisi, Tanna, New Hebrides, 1887-1892—continued.

Date.	Place.	Time (Local).	Apparent Direction.	Apparent Duration.	Effects—Remarks.	Intensity (Rossi-Forel Scale).
1891. Aug. 9	Weasisi (Island of Tanna	3-40 P	—	—	Sharp; felt in house, not in work- shop	IV.
" 19	"	4-3 P	—	—	Slight. Activity in crater, but not so much as in July	II.-III.
Sept. 8	"	7-45 A	—	—	Slight prolonged	II.-III.
" 18	"	6-30 P	—	—	Short sharp shock. One loud erup- tion; four dustfalls	IV.
Nov. 14	"	1-10 P	—	—	Rumbling	III.
" 17	"	5-15 P	N.W. to S.E.	—	Series of long jerks. Heavy erup- tion on night of 16th-17th	IV.
" 23	"	9-0 P	From S.E. or N.W. (?)	—	Double shock, heavier at S.E. corner of house	V.
Dec. 13	"	About 4-0 A	—	—	Heavy	V.
" 14	"	7-45 A	—	—	"Terrific"; house shaken vio- lently and for great length of time	VI.-VII.
" 15	"	1-30 P	—	—	Severe	IV.-V.
" 24	"	1-0 P	—	—	Severe	IV.-V.
" 26	"	1-25 P	From S.E.	—	Severe, but not long. Increase of volcanic activity at beginning of month. Volcano less active since shocks of 13th and 14th	IV.-V.
1892. " 14	Weasisi	5-3 A	About E.S.E. to W.N.W.	—	Sharp and long; horizontal motion; awoke out of sleep ..	V.
Mar. 24	"	About 6 P	—	—	Slight	II.
April 3	"	7-5 P	Not certain, but from S.E. or E.	Perhaps 7 secs.	Slight; rumbling before shock ..	III.-IV.

"	13	"	7-8 P	—	Probably 4 secs.	Sharp; shook a large tray hanging on a nail violently	IV.-V.
"	14	"	12-45 A	—	Say 4 or 5 secs.	Sharp; awakened out of sleep; the lamp shook; lime plaster splintered off walls in places	V.
"	18	"	1-35 P	E.S.E. to W.N.W.	{ 1st, perhaps 2 secs.; 2nd, 3 or 4 secs.	First, very faint; second, sharper; rattled lampshades; first, preceded by rumbling	II. IV.
"	18	"	1-38 P	—	—	—	II.(?) IV.
"	23	"	At night	W. to E.	About 2 secs.	Felt only by Mrs. Gray ..	VI. V.
"	24	"	1-25 A	—	—	—	IV.
May	3	"	6-0 A	N.N.E. to S.S.W.	Say 6 secs.	Severe; awakened from sleep ..	VI. V.
"	9	"	7-45 A	—	About 1 min.	Shook house and furniture; water in tank severely shaken; sea became quickly crested	IV. V. V.
"	12	"	10-55 P	N. to S.	4 secs.	Sharp ..	IV.
"	12	"	11-18 P	"	10 secs.	Sharp and long ..	V.
"	13	"	1-55 P	N. and S.	Say 5 secs.	Shook water-tank violently ..	V.
"	14	"	9-38 A	—	—	Slight; shook a window ..	III.-IV.
"	15	"	4-20 P	{ Both probably from S.E.	2 secs.	First was sharp, and made upper timbers of house creak; second, brief but sharp; circular from right to left; preceded by rumbling sound	IV.-V. IV.
"	15	"	9-51 P	—	4 or 5 secs.	First, shook ground and workshop violently and abruptly; second was not felt in workshop, but shook house violently from the top	V. IV.
"	18	"	2-0 P	From N.	2 secs.	—	—
"	18	"	2-7 P	—	Much longer	—	—
"	20	"	8-50 P	From E.S.E.	—	Neither felt two miles westward; first was with double wave; first, somewhat sharp; second, long and light	III.-IV. III.
"	20	"	9-2 P	From W. to E.	—	—	—

Earthquake Shocks at Weasisi, Tanna, New Hebrides, 1887-1892—continued.

Date.	Place.	Time (Local).	Apparent Direction.	Apparent Duration.	Effects—Remarks.	Intensity (Rossi-Forel Scale).
1891.						
May 22	Weasisi	4:37 A	From N.	—	Severe; rattled door; woke us all from sleep; whizzing sound	VI.
" 22	"	8:28 P	From N. or W.	1 sec.	Sharp and abrupt; rumbling ..	III.-IV.
" 23	"	11:11 A	From S.E.	10 secs.	Severe	V.
" 24	"	3:24 P	From S.E. (?)	About 3 secs.	Worse before shocks; very severe	VI.
" 24	"	4:0 P	—	—	Slight	II.-III.
" 24	"	4:5 P	—	—	More noise than motion	III.
" 24	"	5:14 P	—	—	—	II.
" 24	"	11:29 P	From S.E.	30 secs.	Alarming severe; shook house as one might shake a toy; a door unlatched itself and opened; preceded by a noise, and followed by two tremors about two minutes apart; motion rapid	VII.
" 25	"	After 2:0 A	—	—	Two shocks; first shook house ..	IV., III.-II.
" 25	"	10:24 P	From N.E. (?)	3 secs.	Sharp; made house sway	III.-IV.
" 26	"	1:5 A	"	—	Sharp; shook house	IV.
" 26	"	10:40 P	—	—	Only a tremor	I.-II.
" 27	"	12:30 P	—	—	—	III.
" 27	"	1:25-30 P	From N.	30 secs.	Severe; shook house, rumbling ..	IV.
" 27	"	1:48 P	—	—	Slight	II.
" 27	"	1:53 P	—	—	More severe	II.-III.
" 27	"	1:58 P	—	—	With noise	II.-III.
" 27	"	5:28 P	From N.	—	Sharp; shook house	III.-IV.
" 28	"	1:30 A	From N. (?)	—	Sharp; shook house and woke us	V.-VI.

" 31	"	About 11.15 P	—	4 secs.	Slight; preceded by rumbling ..	III.
June 1	"	4.20 A	From N. (?)	3 secs.	Sharp; shook house and woke us	V.-VI.
" 1	"	1.13 P	—		Only a tremor, with noise ..	I.-II.
" 1	"	10.6 P	From E.	About 1 min.	Severe; shook house, doors flapped, bed quivered (up and down) for more than 30 secs. after shock passed; long and slow	V.
" 2	"	12.56 P	From W.	Long	Severe; shook house; motion long and slow, accompanied by noise	V.
" 2	"	2.45 P	—	—	Slight; floor quivered	II.
Aug. 9	"	About 5.0 A	From N.W.	—	Long slow shock; awoke us, things quivered for some seconds after	V.-VI.
" 11	"	10.40 P	N.	Very short	Slight; double shock, door shook	IV.
Oct. 29	"	7.40 P	From S.E.	2 or 3 secs.	Slight; house quivered, preceded by rumbling	III.-IV.
" 30	"	About 4.0 A	—	—	Slight; woke one sleeper ..	IV.
Nov. 7	"	11.30 P	—	Short	Jerked bed	IV.
" 12	"	8.6 P	From S.S.E.	30 secs.	Severe; shook house and furniture, preceded by rumbling	V.
" 29	Kwamera	9.10 A	—	—	Sharp; shook house	IV.
Dec. 15	Weasisi	4.21 P	From N.N.W. (?)	4 secs.	Shook house violently and suddenly	V.
" 21	"	8.15 P	From S.E.	3 secs.	Shook house slightly, preceded by rumbling	III.-IV.
" 23	"	5.15 A	E. and W.	Say 15 secs.	Bed swayed from side to side, woke out of sleep	V.-VI.
" 23	"	12.15 P	From W. to E.	30 secs.	Very severe; building, doors, fences swayed slowly, but greatly, preceded by rumbling	VI.
" 24	"	11.25 P	—	5 secs.	Sharp; sudden, preceded by noise	III.-IV.

PROGRESS REPORT ON THE SYSTEMATIC CONDUCT OF THE PHOTOGRAPHIC WORK OF GEOLOGICAL SURVEYS.

Members of Committee.

MR. E. P. BISHOP
PROFESSOR TATE
SIR JAMES HECTOR

MR. F. BELSTEAD
MR. J. M. HARVEY
(Secretary).

Owing to the great distances by which the centres of the various colonies are separated, the members of this Committee have had no opportunity of meeting and exchanging their views in the ordinary manner. The draft report was submitted to each of them, and it has been deemed prudent to place on record such of the items as have been adopted, leaving the remainder to be dealt with in the next report. The work hereinafter noticed is that of the photographing and reproduction of objects of purely geological interest, but in the following report the application of photography to topographical surveying will be introduced, and a simple and systematic method of conducting a survey by means of the camera will be described.

Apparatus.—This should be in all particulars as near perfection as it is possible to make it. The camera (at any rate all the main working parts of it) should by preference be made of metal, and should be constructed so as to work with extreme accuracy; no such accessories as swing back, swing front, or side swings are allowable. The tripod head should be large, so as to ensure rigidity, and should be so constructed as to admit of being levelled in the same manner as a theodolite, and it should always be carefully levelled previous to making the exposure. A compass should also be attached, so that the direction of any view can be determined. The size recommended is what is known as “half-plate” ($4\frac{3}{4}$ in. x $6\frac{1}{2}$ in.), this being a reasonable and useful size for practical work when ordinary flat photographs are used; at the same time it lends itself admirably to the production of stereoscopic work, and, again, it is a size always in the market. Lenses of “symmetrical” or “rectilinear” pattern must be used in order to avoid distortion, and the equivalent focal length of each lens must be accurately determined, and this together with its “optical centre” should be engraved on the mount. Several pairs of lenses of different focal lengths should be attached to each outfit. The recently-introduced “tele-photo.” lens

will, when the atmospheric conditions are favorable, give valuable results when views of distant objects are required, and it should be added. (In exceptionally rough country it has been suggested that a quarter-plate camera, $4\frac{1}{4}$ in. x $3\frac{1}{4}$ in., be used in order to reduce bulk and weight. When this is done a tripod top, known as the "Latimer Clark," should be provided in order to produce the stereoscopic negatives.)


Plates.—The plate used should be so treated as to be proof against "halation," and under such circumstances as justify their use "isochromatic plates" should be employed. Rollable films should not be used, as their manufacture has not yet been brought sufficiently near perfection as to ensure accuracy in the resulting negatives.

Reproduction of Prints.—The prints from the negatives should be reproduced in carbon or platinum, as prints of this nature should be permanent.

Nature of Work.—Two exposures should be made on each subject. When the camera is $6\frac{1}{2}$ in. x $4\frac{3}{4}$ in. in size, one of these should be a stereo., the lenses being separated to such an extent horizontally as shall be determined at the time (a record of this distance being kept), and a $6\frac{1}{2}$ in. x $4\frac{3}{4}$ in. negative taken on the second plate, including either the same angle as the stereo. exposure or such other angle as may be deemed desirable, but in taking it the camera should be pointed in the same direction as for the stereoscopic negative. The front of the camera must possess means for altering the distance between the centres of the lenses laterally. The half-plate negative may be printed from, and the print mounted so as to allow of examination as a diagram, the prints from the other negative being trimmed and mounted in the usual manner for the lenticular stereoscope. The photographs of all fossils should also be executed so as to form subjects for the stereoscope, though in this case often the stereo. negative will be found sufficient. A scale should always be attached, so that the actual size of the fossil can be seen. Sufficient reasons for the photographing of the subjects in this manner were advanced in the paper read at the Hobart meeting by the Secretary to this Committee, and an additional reason is that, should any accident happen to a plate in transit, the other always remains to be made use of. In all cases the very best technical work is absolutely necessary; no wrongly exposed or carelessly developed negative should be allowed to find a place in the collection, and in order to make certain of this photographers of the greatest ability and experience should be chosen to do the work. These men will in many cases be found already in the Civil Service of the colonies, so that, if their services are availed of, no extra expense to the State will be involved.

Field Work.—In making a set of photographs of a particular district a plan of the locality should be set down, and the various photographs which have been taken from points within its area

may be mounted upon the same sheet with it, every photograph being distinguished by a sign. The position from which each view was taken should then be plotted accurately on the plan, and the direction in which the camera was pointed indicated, as should also be the focal length of the lens with which the view was taken, and in the field should be included one or more graduated staffs, so as to convey an impression of the scale of the objects photographed, and the correct position of each of these should also be indicated upon the plan. The value of these detail points will be greatly enhanced if they are sent to the geological surveyor to be colored while the objects are before his eyes. The classification of the collections calls for no special mention, as they would be arranged in such a manner as is most convenient for office work in each colony. The whole of the negatives should be preserved as records, and before any permanent prints are obtained a full size transparency should be made from each, so that any negative may be duplicated should any accident befall it. "Retouching" or "improving" of negatives should not be allowed under any circumstances.



REPORT OF THE RESEARCH COMMITTEE APPOINTED TO COLLECT EVIDENCE AS TO GLACIAL ACTION IN AUSTRALASIA IN TERTIARY OR POST-TERTIARY TIME.

Members of Committee.

CAPTAIN HUTTON
MR. R. L. JACK
PROFESSOR TATE

MR. R. M. JOHNSTON
PROFESSOR DAVID
(Secretary).

I.—AUSTRALIA AND TASMANIA.

By Professor T. W. E. David.

Only two reports have reached me on the above subject—the first by Captain F. W. Hutton, F.R.S., and the other a short statement by Mr. R. L. Jack, which, as it merely records the absence of evidences of ice-action in Queensland in Tertiary or Post-Tertiary rocks, is necessarily very brief.

Queensland.—Mr. Jack states that hitherto he has been unable to detect any evidence of ice-action in Queensland in rocks of Tertiary or Post-Tertiary age, though, as already recorded by him,* there is evidence in the shape of groups of travelled boulders of probable ice-action in the Bowen Series (Permo-Carboniferous). Mr. Jack, however, is of opinion that the extensive tin-bearing drifts at Stanthorpe, near the boundary between Queensland and New South Wales, probably imply a Pluvial Epoch. The evidence is as yet insufficient as to the exact geological age of these deposits, but they are probably either Pleistocene or Pliocene, these terms being used of course to express only a general homotaxial relationship to beds of that age. Biological arguments are in favor of a Pluvial Epoch in Queensland. Mr. R. Etheridge, jun., has called my attention to the fact that crocodilian remains referable to *Pallimnarchus pollens* have been recorded by Mr. C. W. de Vis from the Condamine beds (late Tertiary or Pleistocene) and also from near Brisbane from a similar geological horizon. Teeth and coprolites of crocodile, also referred by Mr. de Vis to *Pallimnarchus pollens*, have been obtained from the Warburton River (Diamantina).

* Report on the Bowen River Coalfield.

New South Wales.—In New South Wales little additional evidence has been obtained since the expedition of Professor R. von Lendenfeld, Ph. D., to Mount Kosciusko in 1885. Dr. Lendenfeld affirms that in this portion of the Australian Alps (the Kosciusko plateau) evidences of glaciation are to be met with in the shape of smoothed and rounded surfaces, somewhat of the nature of *roches moutonnées*. These evidences are stated to have been most markedly developed in the Wilkinson Valley and on the Abbot Range. No evidence, however, was obtained of rocks grooved or striated by ice, nor was any evidence observable indicative of glacial-action at a level of less than 5,800ft., Mount Townsend, the highest peak of Kosciusko, being over 7,200ft. high. Lately, however, Mr. R. Helms claims to have discovered evidence of moraines and striated rock surfaces at Mount Kosciusko at a lower level. As far as I am aware, no evidence of Tertiary or Post-Tertiary glacial-action has been observed anywhere outside of the Kosciusko plateau of New South Wales. The Government Geologist of New South Wales (Mr. C. S. Wilkinson) was of opinion that there was undoubted evidence of a Pluvial Epoch in late Tertiary or Pleistocene time in New South Wales on stratigraphical and biological grounds. The widespread deposits of red sandy clays and quartz gravels which cover such a vast area on the western plains of New South Wales indicated, in Mr. Wilkinson's opinion, a far greater volume in our western rivers in flood-time than they have ever been known to possess in historic time. Mr. Wilkinson* states:—"The alluvial deposits of diluvial origin forming over vast western plains, those high terrace banks of gravel along our river valleys, the deeply-eroded ravines carved out on the sides of our mountains, all plainly tell of a time of great rainfall since the Pliocene Period. The heavy precipitations then covered Mount Kosciusko and other of our Alpine peaks with perennial snow, strong rivers coursed down the valleys, and their flood-waters, reaching the low-lying country and becoming confluent, spread out far and wide over it and deposited their burden of muddy sediment to form the level plains of the western interior, over extensive portions of which the highest floods of to-day never reach, and wells or artificial reservoirs have now to be made to supply water for stock." With Mr. Wilkinson's general conclusions I quite concur, but consider that the evidence as to these plains being Post-Pliocene is insufficient, as portions of them are probably at least as old as the Pliocene. At Cuddie's Springs, near Brewarrina, teeth of crocodile have been found apparently smaller than those of *Pallimnarchus pollens*, but of equal value as evidencing the existence in late geological times of extensive marshes in what is now a semi-arid region. Evidence has been obtained by Mr. H. C. Russell, F.R.S., at Lake George, in New South Wales, that that lake, which at present has no outlet, has, in late geo-

* Anniversary Address to Royal Society of New South Wales, May 2nd, 1888.

logical time, been of far vaster extent, implying a heavier rainfall. The wide distribution of *Diprotodon* over not only New South Wales, but over nearly the whole of Australia, also probably implies a humid climate or Pluvial Epoch, giving rise to the development of extensive marshes. Remains of *Diprotodon* have been found in New South Wales from near Queanbeyan on the east to near the borders of South Australia in the west; and in Victoria at Limeburners' Point, near Geelong, at Portland, and at Colac; and in South Australia in the mammaliferous drift described by Professor Tate as underlying in places the tuffs of Mount Gambier and as developed on the banks of the River Torrens near Adelaide. And northwards *Diprotodon* must have ranged at least as far as the Kimberley goldfield in Western Australia, as described by Mr. Hardman. There is, therefore, clear evidence in New South Wales, both stratigraphical and biological, of an epoch when the rainfall was more abundant than it is at present, but whether this Pluvial Epoch was in Pliocene or in Pleistocene time the evidence at present forthcoming is inconclusive.

Victoria.—In Victoria Mr. Stirling, F.G.S., has confirmed Professor Lendenfeld's views as to evidence of glaciation in the Australian Alps, at Mitta Mitta, the Cobberas, Mount Bogong, Omeo Lake basin, &c., but no undoubted evidence seems to have been observed by him similar to that observed by Professor Tate at Hallett's Cove, near Adelaide. Messrs. Graham, Officer, and L. Balfour claim to have lately discovered glacial conglomerates as low as 750ft. above the sea; but I believe that it is possible, if not probable, that the horizon of these conglomerates belongs to that of the Bacchus Marsh and Wild Duck Creek conglomerates, and may therefore probably be Permo-Carboniferous, as at Bacchus Marsh. *Gangamopteris*, so characteristic of the Permo-Carboniferous series of New South Wales, has been found in some numbers.

Tasmania.—An excellent summary of glacial-action in Tasmania and of glacial-action in Australia is given by Mr. R. M. Johnston, F.L.S., in his paper entitled the "Glacial Epoch of Australasia."* Mr. Montgomery, M.A., the Government Geologist of Tasmania, has also contributed an important paper on the subject of glacial phenomena in the vicinity of Mount Pelion and Lake Eyre. Moraine stuff and perfect *roches moutonnées* are described by him, together with erratics, as traceable to from 2,000ft. to 2,792ft. above the sea. Mount Tyndall, on the authority of Mr. Moore, is polished and striated at an altitude of 3,850ft.. At Lake Dixon also, and other localities mentioned in Mr. Johnson's carefully-compiled paper, there appear to be undoubted evidence of glacial-action.

South Australia.—Evidence of ice-action in South Australia has been so fully described already by Professor Tate as to need no further comment. Mr. R. Etheridge, jun., who has personally

* Papers and Proceedings, Royal Society of Tasmania, 1893.

examined the classical locality at Hallett's Cove, informs me that he thinks it not improbable that the glaciated rocks extend under the Marine Tertiaries at Hallett's Cove. This question will no doubt be settled during the present Session of the Association.

II.—NEW ZEALAND.

By Captain F. W. Hutton.

PLATE I.

Although there is a large mass of ice in the old crater of Ruapehu (8,878ft.) in lat. $39^{\circ} 12'$, it is not a true glacier, for accumulation is prevented by melting at the present crater, and no marks of ancient glaciers have ever been found on Ruapehu or in any other part of the North Island. These are confined to the South Island alone.

At the present day the most northerly glaciers in New Zealand are on Mount Armstrong, Mount Greenlaw, and Mount Rolleston, at the head of the Waimakariri River, in about lat. $42^{\circ} 53'$, the terminal faces of which are not less than 4,000ft. above the sea. The most southerly are a few small ones round the head of the Arthur River, which runs into Milford Sound in lat. $44^{\circ} 40'$. The largest glacier in New Zealand is the Tasman, eighteen miles in length, and averaging somewhat under two in breadth, with its terminal face about 2,500ft. above the sea. On the western side of the mountains, however, the Francis Joseph glacier comes down to about 950ft., and the Fox glacier to within 650ft. of the sea level in about lat $43^{\circ} 30'$. All these glaciers come from the highest group of mountains in the Alps. Further southward, as the mountains become lower, the glaciers become smaller and their terminal faces are at considerably greater altitudes.

Ancient glacier-marks are numerous in the South Island, but their geographical distribution differs much from those of the present day. These ancient glacier-marks are, no doubt, of various ages, but it is difficult to correlate them, and it is uncertain whether they form a continuous and diminishing series from the earliest records to the present day, or whether there have been two or more periods of marked extension of the glaciers. If rock basins be taken as evidence of the former presence of ice, then the old lake basins of central Otago—the Maniototo plains and the valleys of the Ida-burn and Manuherikia—will be among the most ancient of our ice-marks; but as the glacial origin of these old lake basins is disputed it will be better to omit them here.

Another supposed evidence of very ancient ice in Otago is the breccia at Henley, near the mouth of the Taieri River.* This

* Hutton, *Geology of Otago*, Dunedin, 1875, p. 62, and Hector, *Reports of Geological Explorations during 1890-91*, p. 1v.

supposed ancient moraine extends from near Otokaia in a south-west direction to Waihola, a distance of about eight miles. North of the Taieri River it occurs at the sea level and forms rounded hills 400ft. to 500ft. in height, but south of the Taieri it ascends the schist hills, and, at its southern extremity, attains its greatest elevation of 1,200ft. above sea level. It is composed of a confused loose mass of angular fragments of mica-schist, many of the blocks being 10ft. or 12ft., or even more, in diameter. North of the Taieri it is covered on the seaward side, nearly to the top, by water-worn gravels. At the northern end it rests, apparently conformably, on coal beds, which appear to be identical with those of Green Island and of Kaitangata; but south of the Taieri it rests directly on the schists, without the intervention of the coal-bearing series, and at Waihola sands and sandy clays, forming the base of the breccia, have yielded a few marine fossils which appear to be of Miocene age. The local distribution of this breccia, as well as the included blocks being formed of mica-schist like that in the neighborhood and in central Otago, preclude the idea that it has been formed by icebergs; and the only possible explanation seems to be that it is the terminal moraine of a Miocene or Pliocene glacier which came from Waipori and Strath Taieri. This would, no doubt, be accepted as the explanation if it were not an isolated phenomenon. At present its mode of origin must remain *sub judice*.

Omitting the Henley breccia, the other ancient glacier-marks form a connected group of phenomena all through the New Zealand Alps, from Southland to Nelson, the most northerly being around Mount Olympus (5,400ft.) in about lat. $42^{\circ} 52'$. No marks of ancient glaciers have been recorded from the Kaikoura and Looker-on Ranges, although they attain altitudes of from 9,700ft. to 8,500ft. in lats. $42^{\circ} 0'$ and $42^{\circ} 15'$ respectively, and are capped at the present day with perpetual snow. This may be due to these mountains not having been so elevated at the time of the great extension of the glaciers, or it may be due to their narrowness, which did not give sufficient room for a snowfield large enough to produce even a moderate sized glacier.

A.—GEOLOGICAL EVIDENCE.

CHARACTER OF THE ICE-MARKS.

Moraines.—These are the most abundant and the most conspicuous marks that the ancient glaciers have left behind them in New Zealand. It is by their moraines that the former limits of the glaciers have in nearly all cases been traced. Without them there would be very little evidence that the glaciers had ever extended further than they do at present. They are, in fact, the most permanent of all glacier-marks. The ancient moraines, both lateral and termina¹ like the recent moraines in New Zealand,

contain very few scratched stones. They are recognised by their composition and their position. Lateral moraines may sometimes be mimicked by landslips, but there is hardly ever any doubt about the true nature of a terminal moraine.

Kames and Drumlins.—It is doubtful whether any of these exist in New Zealand. Small detached hills, formed of morainic deposits more or less mixed with rounded gravel, occur near the western margin of the Canterbury Plains on either side of the Malvern Hills—Woolshed Hill, Racecourse Hill, and Little Racecourse Hill—but these are certainly not drumlins, and probably they are merely relics of terminal moraines, the greater part of which have been washed away by the rivers.

Erratics.—No true erratics—that is, blocks which have been transported from one drainage system to another by ice—have been recognised in New Zealand. Our erratics are merely large angular boulders brought down the valley, from the sides of which they have been detached; but sometimes they have crossed from one side of the valley to the other. No sea-borne erratics have been noticed.

Till Deposits.—The only kind of till found in New Zealand is what is called “surface-till” or “moraine-till,” characterised by being sandy and containing large angular unscratched stones. This is merely the surface moraine of a vanished glacier. No sub-glacial till or boulder-clay—characterised by being formed of tough clay containing more or less rounded stones generally scratched or faceted—has as yet been recorded. Neither is there any stratified floe till. Even the ancient moraines of the west coast, which stretch into the sea and form cliffs along the shore, show no stratification, and no marine shells have ever been found in them.*

Roches Moutonnées and smoothed Surfaces.—These are not uncommon, and are particularly noticeable and fresh looking in the valley of the Rakaia, and in parts of N.W. Nelson district. In Otago the rock surfaces have undergone much more weathering than further north. This may in part be due to differences in the nature of the rocks, and in part to differences in climate, and consequent differences in the rate of weathering.

Ice Grooves on Bedrock.—A few cases on the sides of valleys have been recorded, but none on the tops or near the tops of ridges. Possibly this may be due to the absence of a protecting cover of boulder clay.

Conclusion.—It appears, therefore, that the ice age in New Zealand consisted of a great extension of the valley glaciers of the South Island, and that there is no evidence of the former existence of an ice sheet, or of any floe ice or icebergs in the New Zealand seas. Also there is no proof that any of the glaciers, even at the period of their greatest extension, reached into the sea.

* Haart, *Geology of Canterbury and Westland*, p. 378; and Hutton, *Ann. and Mag. Nat. Hist.*, ser. 5, vol. 15, p. 87.

THE ANCIENT GLACIERS OF NEW ZEALAND.

A few details of what we know about the ancient glaciers of New Zealand may be interesting, and I will begin with Nelson and work southwards.

Nelson.—The most northerly ice-marks yet discovered are near Mount Olympus, in Collingwood county. I have not seen them myself, but they are thus described by Mr. James Park, F.G.S.:—"Glacier detritus is found only in the upper basin of Big Boulder River, where it covers an area of perhaps 150 acres in extent. The morainic matter occurs mostly on the west side of Boulder Lake at the eastern foot of Lead Hill, but the remains of old moraines, principally composed of large angular fragments of granite, are found on the opposite side of the lake resting upon the slates. It is evident that at one time this valley was occupied by a large glacier, which must have excavated the fine rock basin in which the present lake rests. The line of *roches moutonnées* on the west side of the lake near the outlet are as fine an example of ice-erosion as anything of the kind to be seen elsewhere in New Zealand."*

Mr. A. D. Dobson, who was the first to call attention to these ice-marks, says that Boulder Lake, or Te Warau, is 3,200ft. above sea level, and that Lead Hill is a mass of granite, which rises to a height of 4,450ft. above the sea. The glacier, when it attained its fullest size, was about four miles long.†

Several other small glaciers also formerly existed in the same district at the heads of the Anatoki River.

"The Mount Arthur Range, which attains its greatest height (5,800ft.) in the Mitre Peak of Mount Arthur, gave rise to many small glaciers." Those on the eastern slopes descended to 3,600ft. and 3,000ft. above present sea level, while those on the western side were larger and their terminal faces are 3,000ft. and 2,700ft. above the sea. Some of the terminal moraines are almost completely hidden by detritus from the mountains.‡

The St. Arnaud and Spencer Mountains, which rise in places to over 8,000ft. above the sea, gave origin to many glaciers. The principal ones on the north-west were those which filled the valleys now occupied by Lakes Rotoiti and Rotorua. Lake Rotoiti is 2,060ft. above the sea, and its former glacier was about twelve miles in length by two in breadth. On the eastern side a glacier came down the Rainbow River, which is a branch of the Wairau, and others down the Clarence and Waiau-ua. The old glacier of the Waiau-ua or Dillon must have been not less than fourteen miles in length, with a branch five miles long in the valley of the Ada. The terminal moraine at one time held back a lake which

* Reports Geol. Exploration, 1888-9, p. 242.

† Trans., N.Z. Inst., vol. 4 (1871), p. 337.

‡ Dobson, l. c., pp. 338-9.

has been entirely filled up, the moraine rising to about 100ft. above the old lake deposits.*

Canterbury.—We now pass over a space of about fifty miles in length in which no ice-marks have been described, although no doubt they exist, and come to the group of mountains which give rise to the Waimakiriri on the east and south and to the Teremakau on the north and west.

The ancient glacier of the Waimakiriri was thought by Sir J. von Haast to have extended for a length of fifty-four miles, reaching as far as the middle portion of the Malvern Hills. But in the valley itself there appear to be no glacier-marks below the junction of the Broken River, neither are there any in the valley of the latter, and it is probable that the morainic accumulations at Little Racecourse Hill and at the junction of the Kowhai with the Waimakiriri may have been brought about by a glacier coming down the Kowhai Valley and fed from the slopes of Mount Torlesse and Big Ben. Lakes Grasmere, Sarah, Letitia, and Blackwater are remnants of old glacier lakes now almost entirely filled up.†

In the valley of the Rakaia the ancient glacier-marks are clearer than in any other part of New Zealand which I have visited, the lateral moraines on the sides of the hills being specially noticeable. It appears to be pretty certain that this glacier, at the time of its greatest extension, debouched on to the Canterbury Plains, and that we have in Woolshed Hill a remnant of its terminal moraine.‡ Lake Coleridge is an excellent example of a rock basin formerly covered by ice, as it has no morainic accumulations at the lower end. It will be difficult to explain the origin of this rock basin except on the theory that it was excavated by the ice. A large lake formerly existed in the Rakaia Valley above the gorge, but it has been filled up a long time. The reason why Lake Coleridge still remains is that it lies outside that part of the valley occupied by the Rakaia, and that it drains back into the Wilberforce so that no stream of any size runs into it. A branch glacier from that of the Upper Rakaia passed by the valley of the Cameron River to Lake Heron and Lake Acland, and emptied into the valley of the Rangitata between Mount Harper and the Moorhouse Range.§ Sugar Loaf, near Lake Heron, shows admirably the height to which the ice of this glacier reached. After it had melted away a large lake was left, of which Lake Heron is but a remnant. The Rakaia glacier at the time of its greatest extension appears to have been between fifty and fifty-five miles in length.

* Hutton, Reports Geol. Explorations, 1873-4, p. 52; Travers, Quar. Jour. Geol. Soc., vol. 22, p. 254, and Trans., N.Z. Inst., vol. 6, p. 297; McKay, Rep. Geol. Explorations, 1878-9, p. 121; Cox, Rep. Geol. Explorations, 1884-5, p. 9.

† Haast, Report on Geology of Canterbury and Westland, pp. 212 and 391; Report Geol. Exploration, 1871-2, p. 31-35; Hutton, Trans., N.Z. Inst., vol. 16, p. 449, and vol. 19, p. 395.

‡ Haast, Report on the Head-waters of the R. Rakaia, Christchurch, 1866; Rep., Geol. Exploration, 1871-2, p. 32; Geol. Canterbury and Westland, p. 386; Hutton, Rep., Geol. Explorations, 1873-4, p. 52; Cox, Rep., Geol. Explorations, 1883-4, p. 43.

§ Haast, Rep. Geol. Explorations, 1873-4, map opposite p. 10; Geol. Canterbury and Westland, Christchurch, 1879, p. 387; Cox, Rep. Geol. Explorations, 1883-4, p. 43.

The Upper Rangitata Valley I have not visited, but Sir Julius von Haast says that this glacier, during the time of its greatest extension, reached "several miles into the Canterbury Plains, crossing the front ranges, before the lower gorge was cut, by a saddle to the south of it.* Sir J. von Haast recommends the banks of the Potts River as a good place for studying the glacier deposits, one of which he thinks to be a ground moraine, the only one as yet noticed in New Zealand. The Rangitata glacier is estimated to have been forty-eight miles in length. The head waters of the River Waitaki includes the basins of Lake Tekapo, Pukaki, and Ohau, and the ancient glaciers descended, undoubtedly, to beyond the lower ends of these lakes; but whether they continued on until they met and, united together, formed a Waitaki glacier appears to be doubtful. Sir Julius von Haast was of opinion that they did do so, and says that the lowest moraine deposits of the Waitaki glacier which he was able to trace are situated six miles below the junction of the Hakateramea River, and consequently he makes this ancient glacier to have been 112 miles in length. Mr. McKay, however, doubts this, and thinks that the moraine deposits at Wharekauri and Upper Ferry are local, and have been brought by glaciers from the Kurow and Hakateramea Mountains.† I am inclined to agree with Mr. McKay, because I could see no evidence of a glacier having ever come down the Ahuriri Valley.

Westland.—Lake Brunner is due to the terminal moraine of the ancient glacier of the Teremakau; and the country about Kumara is covered by immense morainic accumulations which have, for the most part, come down the valley of the Hokitika. At Bold Head, a little south of Ross, the morainic accumulations reach the sea level, and continue all along the coast to Bruce Bay.‡ According to von Haast these moraines afford proofs of several oscillations in the glaciers, but no marine shells have been found in them, and it is doubtful if they were deposited at the low level at which they now stand.

Otago.—Both Lake Hawea and Lake Wanaka are bounded at their southern ends by moraines which slope gradually away into the alluvial gravels of the plains below them. Further down the Clutha River a large moraine once existed at the junction of the Lindis, and large angular blocks of rock are found in the river alluvium as far down as Cromwell. These are very conspicuous near Cromwell at the entrance to the Kawarau Gorge. Below

* Haast, *Geology of Canterbury and Westland*, p. 390. See also McKay, *Rep. Geol. Explorations*, 1877-8, p. 108.

† Haast, *Geology of Canterbury and Westland*, p. 389, and *Report on the Head-waters of the Waitaki River*, Christchurch, 1865; and *Quarterly Journal, Geological Society*, 1865, p. 135. Hutton, *Geology of Otago*, Duredin, 1875, p. 88. Mr. McKay, *Rep. Geol. Explorations*, 1881, pp. 60 and 93; Green, *High Alps of New Zealand*, p. 128-134.

‡ Haast, *Geology of Canterbury and Westland*, Christchurch, 1879, p. 392; Cox, *Rep. Geol. Explorations*, 1874-6, pp. 85 and 93.

Cromwell none have been found.* This would give a length of sixty miles to the glacier.

In the days of the old glaciers the Wakatipu Valley did not drain, as at present, into the Clutha, but went due south by Athol into the Oreti. Besides the numerous terminal moraines in the valleys of the Rees and Dart rivers, lateral moraines are found on both sides of Lake Wakatipu. At Kingston there is a large and well-marked terminal moraine, and large angular stones extend as far down as Athol, where they stop. This glacier appears to have been about eighty miles long. According to Mr. A. McKay, the lateral moraines at Lake Wakatipu are found at 1,500ft. above the level of the lake.†

The low land on the eastern sides of Te Anau and Manapouri Lakes and across the Mararoa River as far as the base of the Takitimu Mountains is strewn with angular fragments of crystalline rocks, which must have come from the western side of the lakes, and which have, therefore crossed a deep valley; but there are no distinct moraines at the end of either of these lakes. These angular blocks extend down the Waiau Valley to the transverse hills between Red-bank Creek and Blackmount. This hill appears to have been the terminal moraine of the ancient Waiau glacier, which must have been about sixty-five miles in length. According to Mr. S. H. Cox, the ice reached a height of 550ft. above the present level of the water.‡

It is remarkable that throughout Otago the evidence of the former extension of the glaciers is almost entirely confined to moraines, and the ice-marks do not look nearly so fresh as they do in Canterbury. On the other hand, the old glacier lakes in Canterbury are either filled up or have become quite shallow, while in Otago they still remain very deep, and are only partially filled up at their heads.

West Coast Sounds. — Sir James Hector mentions several moraines as occurring up the Cleddau Valley, in Milford Sound,§ and probably they exist in most of the valleys running up into the mountains. It is also probable that the bars at or near the entrances to the sounds are old terminal moraines, although it is possible that they may be due, in part at least, to ancient river-bars which would be formed when the land was at a higher level. Evidence of former glaciers in Preservation Inlet is found in the large boulders of pink syenite which are scattered over the islands and sides of the inlet near its entrance,|| which must have been brought down the inlet by ice. Sir James Hector has recorded (l.c., p. 458) grooves and polished surfaces caused by ancient

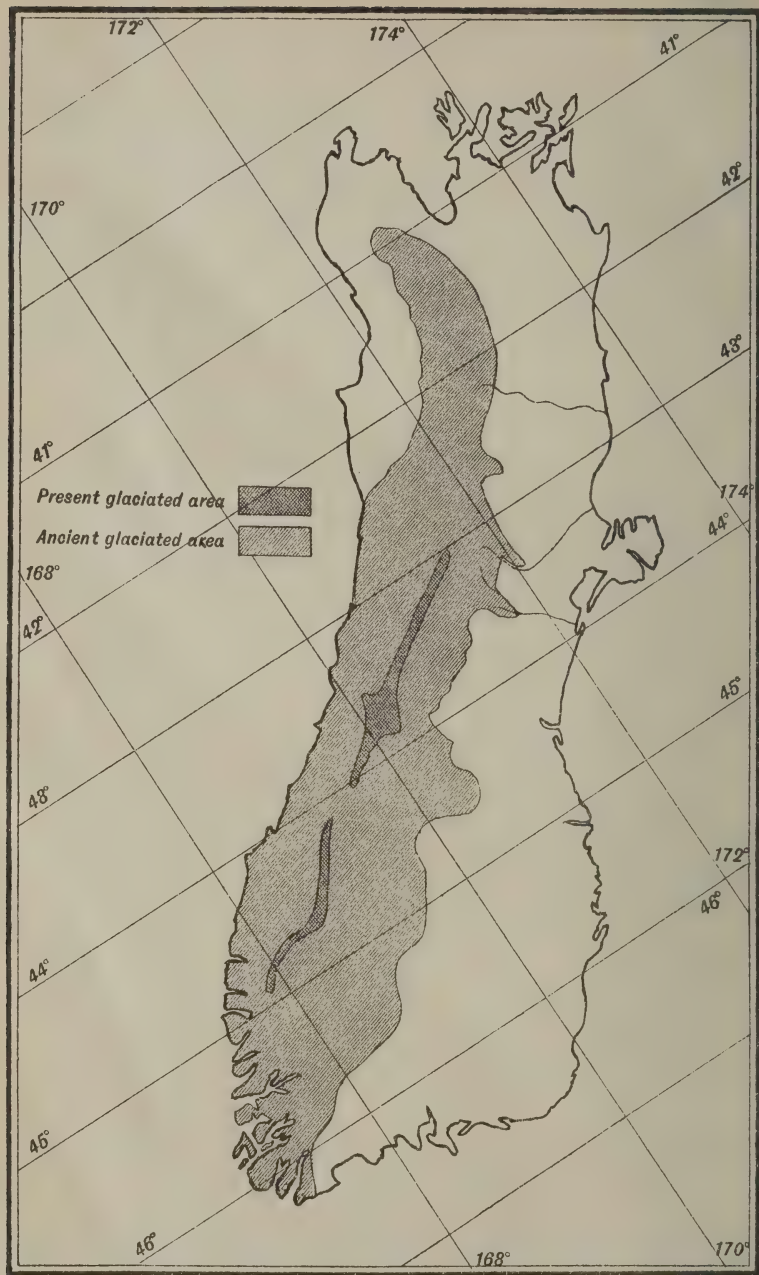
* Geology of Otago, Dunedin, 1875, p. 69.

† Reports, Geological Explorations, 1879-80, p. 146.

‡ Rep. Geological Explorations, 1877-8, p. 118.

§ Geological Expedition to West Coast of Otago. Provincial Government Gazette, Nov. 5th, 1863.

|| Hutton, Report on the Geology of Otago. Dunedin, 1875 p. 68.



glaciers in Thompson Sound; and near Deas Cove, as well as on the south side at the entrance to the Narrows, in Milford Sound, the rocks are rounded as if they had been smoothed by ice. But this may be deceptive, and the rounded surface may be due to the decomposition of a granitic rock. Certainly the islands in the sounds are not now mammillated or ice-smoothed, and they show no sign of lee and strike sides, which is, no doubt, due either to the wet climate, or to the great length of time which has passed since glaciers filled the valleys; or perhaps to a combination of both causes. In either case it is difficult to believe that ice grooves would still remain on rocks which are not covered by clay.

Conclusion.—It thus appears that at the time of their greatest extension the ancient glaciers of New Zealand were larger and descended lower the further they were south. The terminal moraines in N.W. Nelson go to 2,700ft. above the present sea level; Lake Rotoiti, in S. Nelson, to 2,000ft.: Lake Sumner, probably a glacier lake, is 1,700ft. above the sea. In S. Canterbury the terminal moraines are 1,000ft. and in S. Otago only 600ft. above the present sea level. In Westland and in the West Coast Sounds the glaciers advanced to below the present sea level. The glacier of Boulder River was four and that of Lake Rotoiti about twelve miles in length; the glacier at the head of the Waiau-ua or Dillon, fourteen miles; that of the Rakaia, fifty-five miles; the Wanaka glacier, sixty; that of Wakatipu, eighty; and that of Te Anau, sixty-five miles in length. There is, therefore, a considerable difference in relative proportion between the ancient glaciers and their present representatives, as a glance at the map (Plate I.) will show. At present they reach their maximum in South Canterbury, and get smaller both to the north and to the south; while in ancient times their maximum was in Central Otago. This difference may, perhaps, be due to the Otago mountains having then been relatively higher than they are at present; or it may have been due to the great breadth of mountains, at present from 4,000ft. to 7,000ft in height, in central Otago, which were probably covered with snow during the great Glacier Period.

B.—BIOLOGICAL EVIDENCE.

In Europe and North America the geological evidence of a former ice-age is accompanied by the biological evidence of a southerly migration of arctic shells, which subsequently became extinct as the ice-age passed away. In New Zealand we find nothing of this kind of evidence, for the mollusca of the Pliocene and Pleistocene beds show no sign of a refrigeration in climate.* Indeed several of our living shells, which are not now found in the seas of the southern parts of New Zealand, occur in Miocene beds; consequently it would seem probable that the climate of the

* Trans. N.Z. Institute, vol. VIII., p. 385.

northern parts of New Zealand has never since the Miocene been as cold as that of the southern part at the present day. Indeed, a large part of the present sub-tropical fauna and flora of New Zealand was introduced from the north before the Miocene Period and has flourished ever since; and this would not have been possible if there had been a great and general reduction in temperature in the Pleistocene Period.

Again, the islands lying south of New Zealand contain a large number of endemic species of plants and some animals. For example, a paroquet (*Cyanorhamphus unicolor*) on Antipodes Island, a duck (*Heronetta Aucklandica*) on Auckland Island, and a rail (*Rallus Macquariensis*) on Macquarie Island. These facts prove that the islands have been disconnected from New Zealand for a very long period, and during that time they could not have been covered by ice.

Lastly, we have the local occurrence of some of the warmth-loving plants and animals of the North Island in isolated places in the South Island—such as the New Zealand palm (*Areca rapida*) at Akaroa, and several North Island shells in Stewart Island*—which is hardly compatible with the occurrence of a former cold epoch, but points to a gradually cooling climate.

The biological evidence is, therefore, to the effect that the ocean round New Zealand has not been much colder than at present ever since the Miocene Period.

* Pro. Lin. Soc., N.S. Wales, vol. x., p. 338.

REPORT OF COMMITTEE APPOINTED TO MAKE RECOMMENDATIONS FOR THE PROTECTION OF NATIVE FAUNA

(AS AMENDED AND APPROVED BY COUNCIL).

Members of Committee.

PROFESSOR TATE	COLONEL LEGGE
PROFESSOR SPENCER	MR. G. M. THOMSON
MR. A. J. CAMPBELL	MR. A. F. ROBIN
MR. S. DIXON	(Secretary).

The Committee desire to make the following recommendations for the approval of the Association:—

1. That close reserves, controlled by local honorary trustees and supported by Government grants, should be proclaimed as under—

- (a) New Zealand—Resolution and Little Barrier Islands. The Committee would express their cordial approval of what has been already done by the New Zealand Government with regard to these reserves, and hope that they will speedily be finally dedicated in accordance with the resolution carried at the Christchurch meeting of the Association in 1891. They also consider that islands should be set apart for the preservation of the Tuatara lizard.
- (b) Tasmania—Schouten Main (Freycinet Peninsula). This is recommended as the Tasmanian National Park.
- (c) South Australia—It is urged that the lighthouse reserve at the western end of Kangaroo Island should be dedicated to the preservation of native fauna.
- (d) Queensland—Mount Bellenden-Ker, and part of Fraser Island to be hereafter determined.
- (e) Western Australia—Rottnest Island (more particularly for the protection of the mallee hen), Houtmann's Abrolhos Group.
- (f) New South Wales—Cave reserves.
- (g) Bass's Straits—The Committee consider that the Victorian and Tasmanian Governments should be requested to draw up a joint Act for the protection of the Cape Barren goose on those islands on which it is found. They are also of opinion that the destruction of the mutton birds for commercial purposes should be properly controlled by Governmental regulations.

2. That the existing game laws should be strictly enforced.
3. That in all Game Acts provision should be made for the proclamation of districts, comprising both Crown lands and private property, wherein particular species may be absolutely protected for indefinite periods.
4. That special legislation should be introduced in all the colonies to provide for the protection of animals of economic value or particular biological interest.
5. That a standing committee of local naturalists should be appointed in each colony to deal with the protection of the native fauna.
6. That copies of the foregoing resolutions be sent to the Australasian Governments with the request that they will give their assistance in carrying them into effect; also to all colonial scientific societies with a request for co-operation and support.
7. The Committee recommend that the following local committees be appointed to prepare systematic lists of the vernacular names of Australasian birds:—

South Australia and Western Australia.—Messrs. Zietz, Perks, Clarke.

New Zealand.—Sir J. Hector, Captain Hutton, Professor T. J. Parker, and Mr. Cheeseman.

Tasmania.—Colonel Legge, Mr. A. Morton, and Rev. H. Atkinson.

New South Wales.—Messrs. North, Masters, and Thorpe.

Victoria.—Mr. A. J. Campbell and Professor Spencer, with power to add one.

Queensland.—Messrs. de Vis and Barnard, with power to add one.
Dr. Stirling, General Secretary.

PROCEEDINGS OF SECTIONS.

Section A.

ASTRONOMY, MATHEMATICS, AND PHYSICS.

1.—ON THE CONSTRUCTION OF PENDULUM APPARATUS FOR DIFFERENTIAL OBSERVATIONS OF GRAVITY.

By E. F. J. LOVE, M.A., Fellow and Rector of Queen's College, Assistant Lecturer and Demonstrator in Natural Philosophy to the University of Melbourne.

[ABSTRACT.]

In this paper the author lays down certain main principles, to which attention should be paid in the design of invariable pendulums. Exception was taken to pendulums of the flexible pattern designed by Kater, and reasons advanced for preferring the more rigid form adopted by von Sterneck. The forms of stand previously employed were also criticised and an improved pattern suggested. The paper concluded with a discussion of the methods adopted for investigating the temperature and pressure corrections.



2.—ON SOME DIAGRAMS SHOWING THE RELATION BETWEEN THE LENGTH OF A SOLENOID AND THE FORM OF ITS EQUIPOTENTIAL SURFACES.

By C. COLERIDGE FARR, B.Sc., Mathematical Tutor in St. Paul's College, University of Sydney.

PLATES II.-V.

Some months ago the author had occasion to design a solenoid, in which the variation of the field strength between the axis and the inside edge for a short distance on either side of the equatorial plane should not exceed a certain amount. For this purpose it

was necessary to draw roughly the equipotential lines in the interior of coils of different lengths, and the curves so obtained proved interesting enough to induce him to go into the calculations more fully and attempt to draw the curves more accurately, both inside and outside the solenoid. The equipotential lines have therefore been drawn for four coils, whose lengths are—(1), $L = a$; (2), $L = 2a$; (3), $L = 4a$; (4), $L = \infty$ (Plates II., III., IV., and V.), where L is the length of the solenoid and a the radius of its transverse section. These coils will be referred to as coils (1), (2), (3), or (4). The formulæ used are given in "Maxwell's Electricity and Magnetism," vol. ii., p. 284, second edition, and are as follows:—

The magnetic potential at any point outside is

$$\Omega = nj(V_1 - V_2);$$

at any point inside it is

$$\Omega = nj(-4\pi z + V_1 - V_2),$$

where

Ω = magnetic potential at the point considered :

n = number of turns of wire per unit of length :

j = current in C.G.S. units :

V_1 = potential at the point due to a plane area of surface density unity at the positive end of the solenoid :

V_2 = potential at the negative end :

z = distance of the point from the centre of the solenoid measured along the axis :

the values of V_1 and V_2 are found from the expressions

$$V = 2\pi \left\{ -rP_1 + a + \frac{1}{2} \frac{r^2}{a} P_2 - \frac{1 \cdot 1}{2 \cdot 4} \frac{r^4}{a^3} P_4 +, \&c., \text{ when } r_1 < a, \right.$$

$$V = 2\pi \left\{ \frac{1}{2} \frac{a^2}{r} - \frac{1 \cdot 1}{2 \cdot 4} \frac{a^4}{r^3} P_2 + \frac{1 \cdot 1 \cdot 3}{2 \cdot 4 \cdot 6} \frac{a^6}{r^5} P_4 -, \&c., \text{ when } r > a. \right.$$

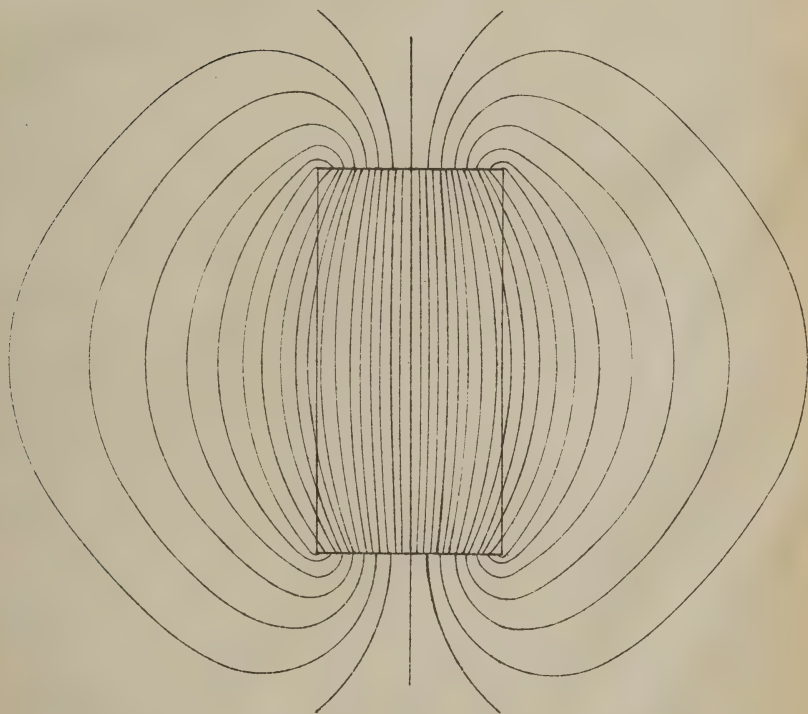
For points along the axis the simpler formula $V = 2\pi(\sqrt{a^2 + r^2} - r)$ was used, where

r = distance of the point from the centre of one of the circular ends of the solenoid.

$P_1, P_2, \&c.$, are the zonal surface harmonics of orders 1, 2, &c., corresponding to the angle θ which r makes with the axis of the coil.

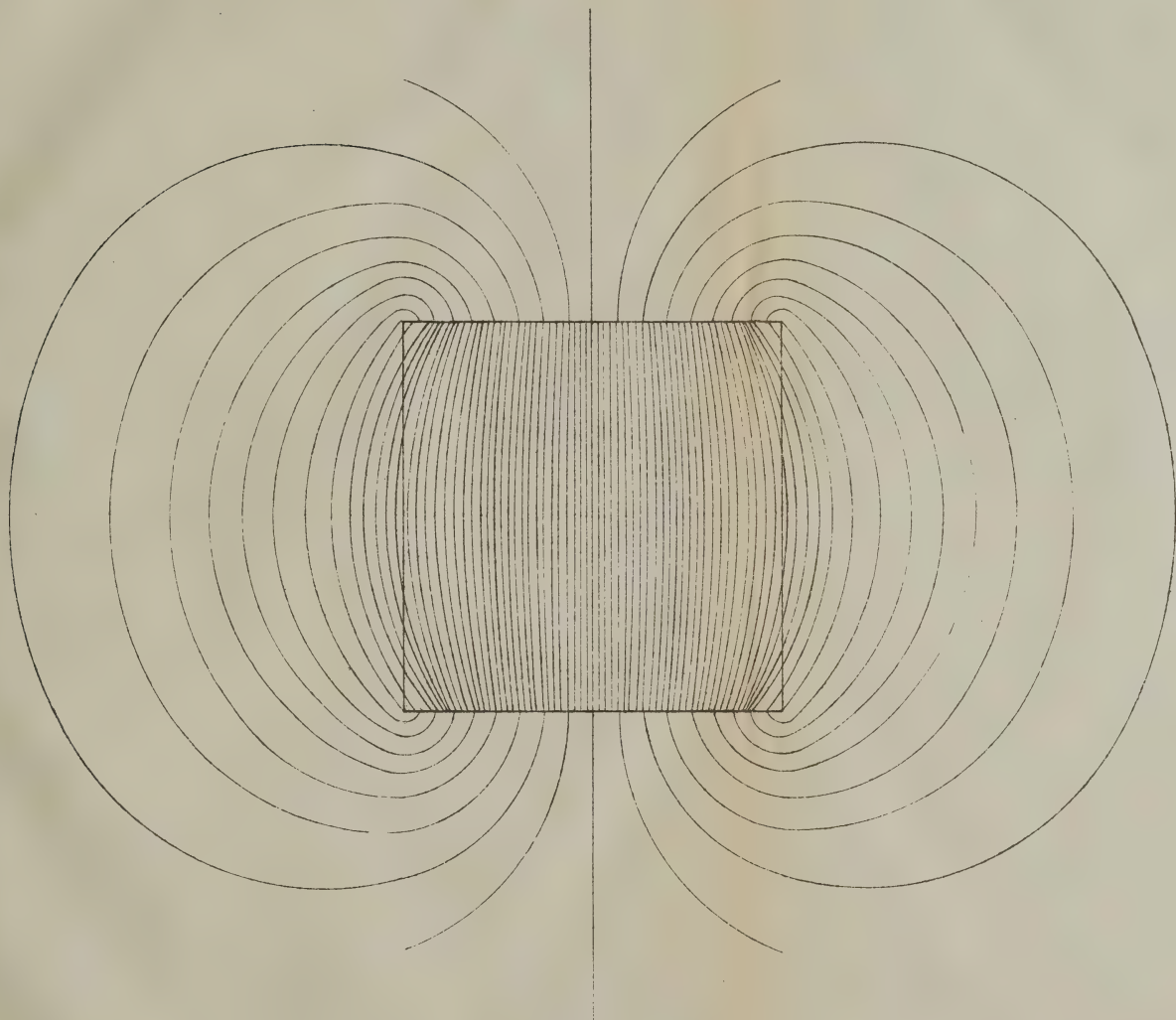
The values of V_1 and V_2 at different points inside and outside the solenoid were worked out by means of these formulæ, and the corresponding values of Ω were thus found for between forty and

Equipotential Lines in a Solenoid



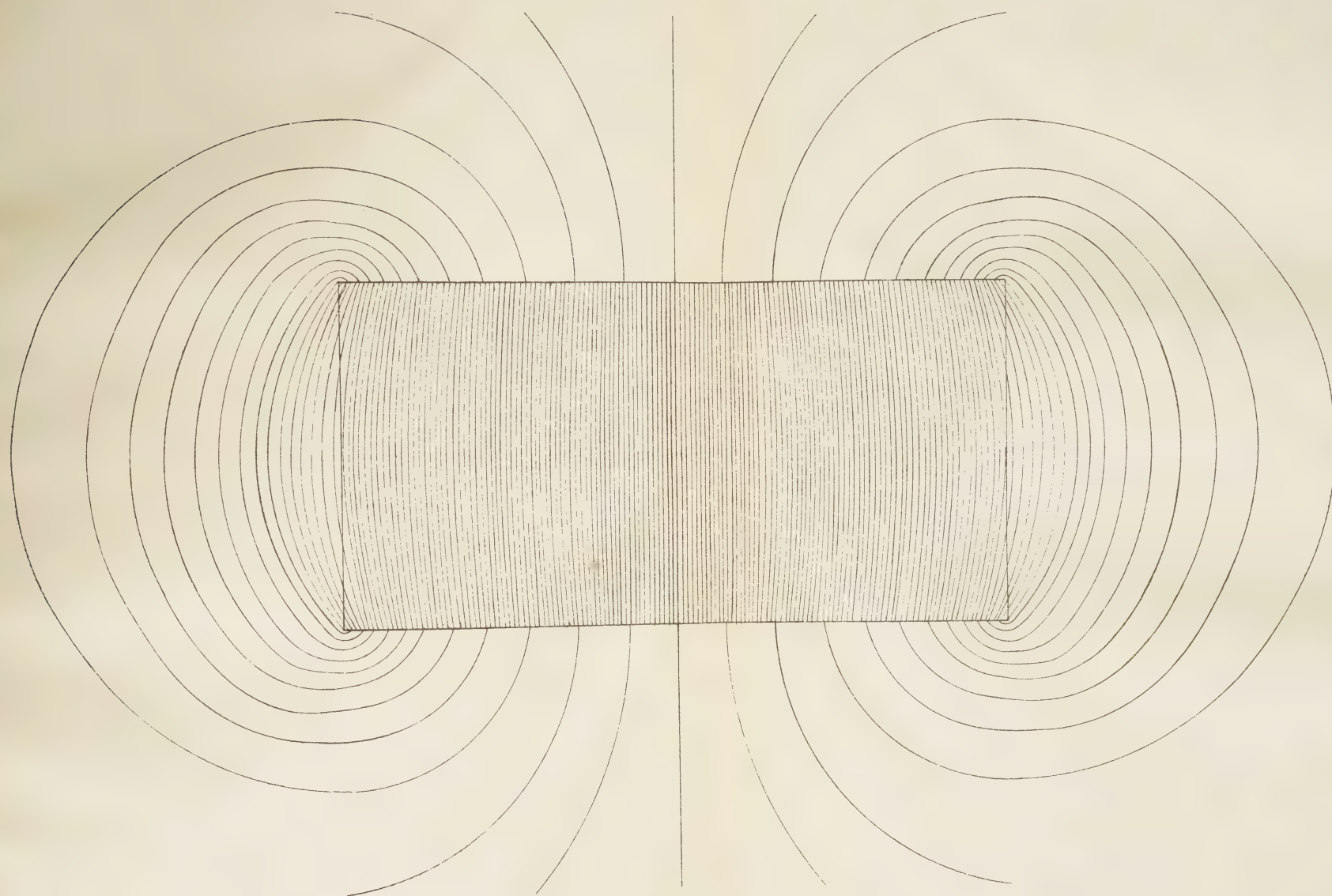
Coil 1. $L = a$

Equipotential Lines in a Solenoid



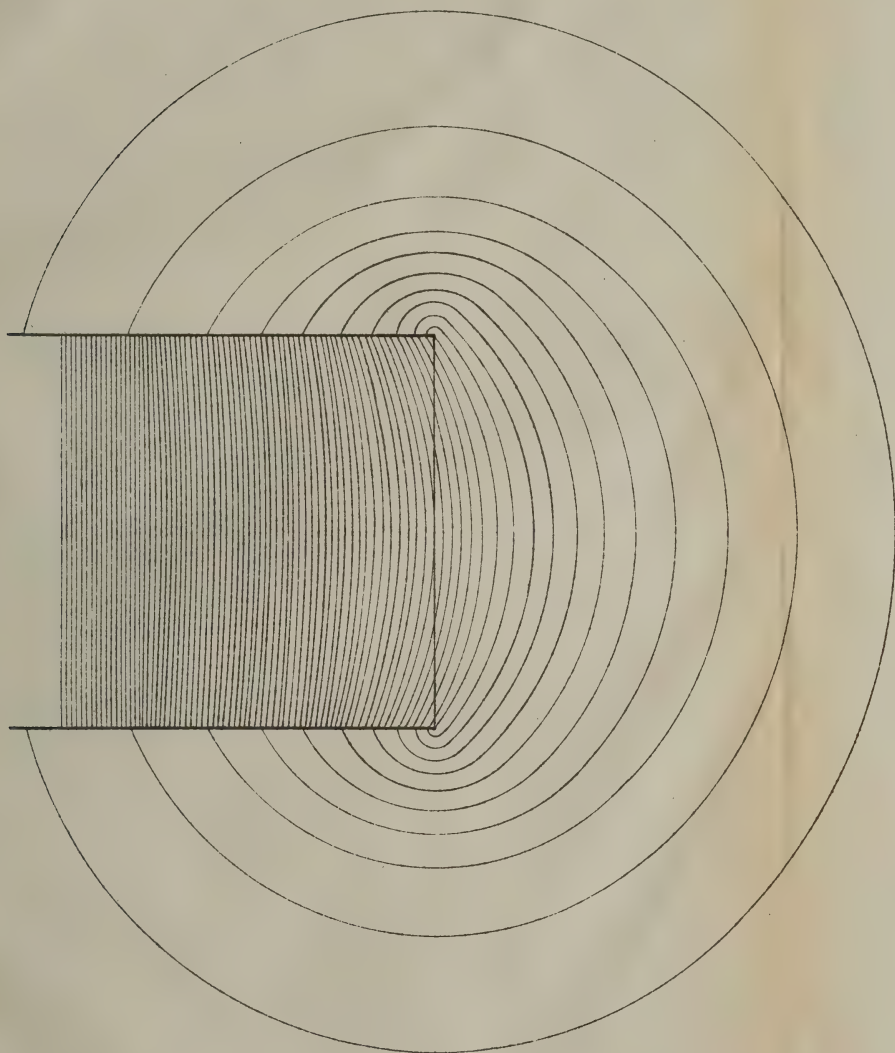
Coil 2. $L = 2a$

Equipotential Lines in a Solenoid



Coil 3. $L = 4a$

Equipotential Lines in a Solenoid



Coil 4. $L = \infty$

fifty points in one quadrant, which, on account of symmetry, gives about 160 points at which the potential was known round the solenoid. The potential at any other point was then found by interpolation. Points whose potential was the same were joined by the curves which seemed best to suit. The spherical harmonics were obtained from a table recently published by Professor Perry*. The difference of potential between points lying on one curve and on the next, both inside and outside, is $2 \pi n j a \times .05$. This difference was chosen as a matter of convenience, $2 \pi n j a$ being in all these coils a factor of Ω . In the three shorter coils the equipotential curves start with a value zero at the equator, increasing positively and negatively respectively on each side by $2 \pi n j a \times .05$ from line to line, both inside and outside. In coil (4), Plate V., the potential inside is infinite, on account of z being infinite. Outside the potential of points on the outermost line is $2 \pi n j a \times .2$, those for $2 \pi n j a \times .15$, $2 \pi n j a \times .1$, &c., going off the paper.

As Maxwell points out, there is a discontinuity in the magnetic potential at the plane ends of the solenoids, but the equipotential surface lines inside at the end are connected with those outside at the end, and the curvative is the same for both.

In some cases it was exceedingly difficult to find curves which passed nicely through the points which had to be joined together, and the drawing was all done at night. The most palpable error, which, however, is not likely to mislead anyone, is to be found in coil (2), Plate III. The spacing of the lines near the corners of the square representing the solenoid obviously requires altering. The curves bring out very clearly the want of uniformity of the field in the interior of short coils, even the first line from the equatorial in coil (1), Plate II., being slightly curved. In the other coils it is uniform for a greater and greater length, as the solenoid becomes longer and longer. In coil (2), Plate III., it is uniform

for a little less than $\frac{a}{8}$ on either side of the central line, in coil (3),

Plate IV., for a little more than $\frac{a}{4}$, while in the case of coil (4),

Plate V., the field ceases to be uniform at a distance $\frac{3a}{2}$ from one

end. Since the curves are all drawn to the same scale, the ratio of the distance between any pair of lines in one coil to that of the corresponding pair in all other gives us the ratio of the magnitude of the force in the second coil to that in the first, so that the curves show also how very much feebler the force is at the centre of the solenoid for a short coil than for a long one which has the same number of turns per centimetre, the same radius of section, and the same current round the coils.

* Phil. Mag., ser. 5, Dec., 1891.

3.—METEOROLOGICAL WORK IN AUSTRALIA : A REVIEW

*By Sir C. TODD, K.C.M.G., M.A., F.R.S., F.R.A.S., Government
Astronomer, Adelaide, S.A.*

PLATE VI.

The object of the present paper is to place before the Association a brief and succinct account of meteorological work in Australia. Mr. Russell has already told us, in his interesting paper on astronomical and meteorological workers, read before the Association at its first meeting in Sydney in 1888, what had been done in the early days of the mother colony, and brings the history up to the year 1860, or immediately following the commencement of the active work of the new observatory completed in 1858, an establishment with which he has been associated during the past thirty-four years, and over which he has so honorably presided since his appointment as astronomer in 1870, on the death of Mr. Smalley in July of that year.

It is unnecessary that I should travel over the same ground. My intention is to carry on the history of which Mr. Russell has already given us the opening chapter. Indeed, as regards meteorology but little had been done before the advent of Mr. Scott, the first director of the Sydney Observatory, in 1858, who, Mr. Russell tells me, established twelve meteorological stations, two of which, Brisbane and Rockhampton, were in Queensland, then forming part of New South Wales. Each station was equipped with a standard barometer, dry and wet bulb thermometers, maximum and minimum thermometers, and a rain gauge.

Meteorological stations had previously—in 1840—been established at South Head, Port Macquarie, and Port Phillip, Victoria being then under the Government of New South Wales. The observations at South Head were kept up, but, I fear, not in a very satisfactory or systematic manner, for fifteen years, or until 1855. At Port Phillip and Port Macquarie they are said to have been discontinued after six years. During Mr. Smalley's tenure of office several stations started by his predecessor, for some reason or other, probably owing to his bad health, were closed or allowed to fall into disuse. These were, however, speedily re-established by Mr. Russell: and I may here mention as showing the active manner in which that gentleman has prosecuted the work commenced by Mr. Scott, that he has now in addition to the Sydney Observatory thirty-five meteorological stations, having barometers, dry and wet bulb thermometers, maximum and minimum thermometers, and rain gauges; 139 stations furnished with thermometers and rain gauges; and 1,063 stations having rain gauges.

The Sydney Observatory is equipped with continuous self-recording barograph and thermograph, pluviometer and anemograph, made after Mr. Russell's own designs, besides underground ther-

mometers at depths of 10ft., 5ft., 2ft. 6in., and 1in.; an evaporation tank, or atmometer, &c.; a record, combined with the valuable astronomical work being done, worthy of the oldest colony of the group, which had already gained distinction in its promotion of science by the Dawes Point Observatory, erected in 1788, and the celebrated Paramatta Observatory, established in 1821 by Sir Thomas Brisbane.

In Mr. Tebbutt, Mr. Russell has found a most valuable coadjutor. That gentleman has not only carried out an extensive series of astronomical observations entirely at his own cost, but also furnished his observatory with a complete meteorological outfit.

In Victoria there were only broken records of rainfall, temperature, and weather, made chiefly by New South Wales officials in Melbourne, from 1840 to about 1849, and of rainfall up to 1851. In 1854 observations of barometer and temperature for astronomical purposes only, and of rainfall, were made at the Williamstown Observatory, then in charge of Mr. R. L. J. Ellery. Meteorological observations were also made at Melbourne by Mr. Brough Smyth, of the Crown Lands Department, from 1856 to the end of February, 1858, when Professor Neumayer, now director of the Nautical Observatory at Hamburg, commenced systematic observations at the new Magnetic and Meteorological Observatory, at Flagstaff Hill, Melbourne. Dr. Neumayer also established several observing stations at the lighthouses on the coast, and at a few places inland.

On the retirement of Dr. Neumayer in 1863, the Magnetic and Meteorological Department was transferred to the present Astronomical Observatory, then just erected, and placed under the direction of the astronomer, Mr. Ellery, in whose hands the institution soon became what it is to-day—not only a credit to the colony which founded it, but second to none in the Southern Hemisphere. He threw all his energy and skill as a physicist into his work, and early introduced photographic and other systems, by which we obtain continuous records of all variations of terrestrial magnetism, barometric pressure, and changes of temperature, electrical states of the atmosphere, and the direction and force or velocity of the wind, besides thermometers sunk at various depths (3ft., 6ft., and 8ft.) to determine the temperature of the ground; while, as regards astronomy, we have only to visit the observatory to see that it possesses some of the finest instruments in the world.

Besides the Melbourne Observatory, he has established meteorological stations of the second order at Portland, Cape Otway, Wilson's Promontory, Gabo Island, Ballarat (Mount Pleasant), Bendigo, Echuca, Sale (at the School of Mines), and twenty-three stations of the third order, besides 515 rainfall stations judiciously distributed throughout the colony.

In South Australia, thanks to the late Sir George Kingston, father of the present Premier, we have a continuous record of the rainfall in Adelaide from 1839, which that gentleman maintained until 1878.

Meteorological observations, more or less complete, were made at the Survey Office for a number of years, or until I took up the work in November, 1856, when the observatory records commenced under my direction as Government Astronomer.

Since May, 1860, all the observations have been made at the West-terrace observatory. For several years I had no assistant, and having a growing Telegraph Department to look after and control, the area of my work was necessarily restricted, and I labored under many disadvantages; but I early established meteorological stations at Clare, Kapunda, Strathalbyn, Goolwa, Robe, and Mount Gambier, and placed rain gauges at the different telegraph offices. I also introduced the system of publishing daily reports of the weather and rainfall from all stations at the head telegraph office in Adelaide.

We have now meteorological stations, having standard or Board of Trade barometers, dry and wet bulb thermometers, maximum and minimum thermometers, and rain gauges, at Port Darwin, Daly Waters, Alice Springs, Charlotte Waters, Strangways Springs, Farina, Port Augusta, Yongala, Clare, Kapunda, the Agricultural College at Roseworthy, Mount Barker, Strathalbyn, Eucla, Fowler's Bay, Streaky Bay, Port Lincoln, Cape Borda, Robe, Mount Gambier, and Cape Northumberland, and 370 rain gauges; at the lighthouses at Cape Borda and Cape Northumberland, and at the telegraph offices at Port Darwin and Alice Springs, the observations are taken every three hours, night and day; at other stations at 9h. a.m., 3h., p.m., 9h. p.m.; whilst at Alice Springs there is a large evaporation tank similar to the one at the observatory, which it may be convenient here to describe.

It consists, first, of a brick tank, lined with cement; internal measurement, 4ft. 6in. square and 3ft. 2in. deep. Inside this tank is another, made of slate, 3ft. square and 3ft. deep, leaving an intervening space between it and the larger tank of 7in. Both tanks are filled to the same level, or to within 3in. or 4in. of the top, fresh water being added as required. The evaporation is measured by a graduated vertical rod, which is carried by a float placed in a vertical cylinder of copper 4in. in diameter (perforated at the bottom) standing in the inner tank. The rod is graduated to $\frac{1}{16}$ of an inch, and is read off by means of a fixed vernier to $\frac{1}{160}$ of an inch. A rain gauge is placed by the side of the tank, and both the evaporation and the rainfall are read at 9 a.m. and 9 p.m.

As the question of evaporation is an important one in connection with water conservation, I give below the mean evaporation at Adelaide, deduced from twenty-three years' observations, and at

Alice Springs, in the centre of the continent, during the years 1890, 1891, and 1892.

Evaporation at Adelaide.		Evaporation at Alice Springs.		
Mean of Twenty-three Years.		1890.	1891.	1892.
	Inches.	Inches.	Inches.	Inches.
January	8·928	—	12·840	14·020
February	7·226	11·200*	13·840	10·550
March	6·035	11·990	11·850	8·720
April	3·599	6·000	5·040	7·180
May	2·1·1	4·760	4·480	4·660
June	1·382	3·150	2·660	3·950
July	1·461	4·440	3·820	4·210
August	2·029	5·430	5·810	5·690
September	3·017	—	7·780	8·170
October	4·859	11·222	8·225	9·845
November	6·499	11·730	9·265	11·870
December	8·359	13·790	12·940	11·490
Year	55·525	—	98·550	100·355

* Twenty-seven days.

Greatest in one year at Adelaide 60·953 inches in 1876.

Least in one year at Adelaide 47·392 inches in 1892.

Average rainfall at Adelaide for fifty-four years 21·077 inches.

Average rainfall at Alice Springs for nineteen years .. 11·254 inches.

In Tasmania the Imperial Government established a magnetic and meteorological observatory at Hobart, as part of an international scheme, in charge of Captain Kay, and systematic meteorological observations were conducted from 1841 to 1854, hourly readings being taken until the end of 1848. The results were published, together with the magnetic observations, in four large quarto volumes with a short but interesting and instructive article by the late Professor Dove, then director of the meteorological stations in Prussia. Similar observatories were established at Greenwich, St. Helena, Cape of Good Hope, and Toronto, besides places in Europe, and by Russia in Asia.

From the beginning of 1855, the Imperial Observatory being closed, meteorological observations at Hobart were carried on by the late Mr. Francis Abbott until about the year 1880, when the Government took up the work, which was entrusted to the late Captain Shortt, R.N., who died last year. Captain Shortt proved a valuable coadjutor, and established eight other observing stations besides a number of rain gauges in various parts of the island, of which there are now about fifty-nine.

In Western Australia a meteorological observatory was established by the Government, in connection with the Surveyor-General's office, the work being entrusted to Mr. M. A. C. Fraser, in 1876, since which continuous records have been published. Prior to the date mentioned we have rain and temperature records at Perth from 1860 to 1869, taken by Mr. H. Knight. At present Mr. Fraser has fifteen meteorological stations, exclusive of Perth, and ninety-one rain gauges. At Perth there is a self-recording barometer, selected by me when in England in 1886. The observations in this colony are very valuable, extending, as they do, from the south coast well into the tropics at Wyndham, Cambridge Gulf.

In Queensland, as has already been stated, meteorological stations were started at Brisbane and Rockhampton by Mr. Scott, the first Government Astronomer of New South Wales. I do not know the exact date, but Mr. Scott arrived in the colony in 1858, and retired in 1862. The instruments were transferred to Queensland on its separation from the parent colony, and for some years the duties of meteorologist devolved on Mr. Edmund MacDonnell, who established several observing stations and a number of rain gauges.

In 1887 Mr. Wragge was appointed, who—with the great ability and energy which characterises him, and which had brought him so much renown in starting, I believe at his own expense, the high level observatory at Ben Nevis, where he conducted the work under difficulties which would have deterred most men—soon effected a complete revolution. Beginning his work on January 1st, 1887, he speedily equipped stations of the several orders all over the colony, along the coast round to the Gulf of Carpentaria, and inland to the very western boundary of the colony. He classified his stations under five orders, according to the completeness of their equipment, as follows:—First order, second order, third order, third order A, third order B.

Stations of the first order are equipped with the following instruments:—Standard barometer, barograph, Stevenson's double-louvred thermometer screen, hygrometers, maximum and minimum self-registering thermometers, thermograph, solar and terrestrial radiation thermometers, earth thermometers, wind compass, and rain gauge. The hours of observation of stations of this order are 3 a.m., 9 a.m., 3 p.m. and 9 p.m. (local time), and also in some instances at the time (depending on longitude) corresponding to mean noon at Greenwich, when synchronous observations are taken at the principal stations throughout the world. The barographs and thermographs are of Richards' construction.

The equipment of stations of the second order is generally the same as above, with the usual exceptions of barograph and thermograph. The observing hours at these stations are 9 a.m. and 9 p.m. (local time).

Third order of climatological stations are supplied with a thermometer screen, hygrometer, maximum and minimum self-registering thermometers, wind compass, and rain gauge. In "A" division the hygrometer is excepted, and in "B" division a rain gauge only is employed. The time of observation at all stations of the third order is 9 a.m., local time.

Following the example of Mr. Ellery, Mr. Russell, and myself, Mr. Wragge commenced the system of publishing daily reports of weather and rainfall, and a synoptic map similar to the map we had for some time been issuing in Adelaide. He also co-operated with us in publishing forecasts of the probable weather during each ensuing twenty-four hours, with this addition, that he issued forecasts not only for Queensland, but also for the other Australian Colonies; and, as these latter were made without regard to those published at an earlier hour by the several local authorities, it has occasionally happened that the two forecasts for the same colony differed from each other. I will not venture an opinion as to the desirableness of this independent action, beyond remarking that supposing the judgment and qualifications of the other meteorologists to be equally good, their local experience, and the possession of more detailed information in regard especially to prognostics, clouds, &c., gives them an advantage, and their forecasts should be of equal value, and be more frequently justified. Of Mr. Wragge's zeal and high qualifications for his special work there can be no two opinions. I regret that his collected observations have not yet been published—from causes, it may be presumed, beyond his control—in such detail as he himself would wish, and which, in the interests of science, we all desire. This is to be regretted, as his stations are so distributed as to represent the climate of all parts of that large colony. There are now in Queensland sixteen stations of the first order, thirty-six of the second order, forty-five of the third order "A," and 398 rain gauge stations, third order "B." Included in the second order are two private stations and five in the third order "A."

Besides the stations in Queensland, Mr. Wragge tells me he has supplied instruments for two stations of the first order in New Guinea, for one in New Caledonia, one in Fiji, and one in Norfolk Island, and two others of the second order in New Guinea.

In New Zealand, I learn from Sir James Hector, that from 1853 meteorological reports were included in the yearly volume of statistics issued by the Registrar-General, but the observations were of irregular character, and possessed little value until 1859, when the work was taken up in a more systematic manner. Observers were appointed at Wanganui, Auckland, Napier, New Plymouth, Wellington, Nelson, Christchurch, and Dunedin, each being supplied with a set of standard instruments. The service appears to have been placed, in the first instance, under the supervision of Dr. Knight, the Auditor-General, but in 1867 it

was transferred to Dr. (now Sir James) Hector, under whose skilful management great improvements were introduced. The principal stations are supplied with mercurial Fortin barometers, dry and wet bulb and self-registering maximum and minimum thermometers, solar and terrestrial radiation thermometers, Robinson's anemometers, and rain gauges. The height of every barometer above sea-level has been ascertained, and every reading, as in the other colonies, is reduced to sea-level and 32° Fahr.

At present there are eight stations, viz., Te Aroha, Taranaki, Russell, The Bluff, Wellington, Lincoln, Hokitiki, and Dunedin, equipped as above, except Te Aroha, which has an aneroid; and seventy-nine rain stations.

To facilitate the transmission of daily weather reports Sir James Hector has prepared a series of isobaric maps, which fairly represents all the different types of weather. These maps are numbered in consecutive order, and stereotyped copies are supplied to each station, so that all that is necessary is for the head office to telegraph to each office the number of the map to be posted up for the information of the public. In the same manner typical maps of the pressure in Australia have been prepared, with the assistance of Mr. Russell, of Sydney. The reports from a few selected stations, a brief description of the weather, and the number of the map are daily exchanged between Wellington and Sydney (representing Australia); the New Zealand reports being transmitted by telegraph to the head office in each of the other colonies.

Spread throughout the colonies we have 357 meteorological stations, more or less completely equipped, and 2,575 rain gauges.

It will be seen that, excepting the magnetic and meteorological observatory at Hobart, established in 1841, which was an Imperial institution, systematic observations under the auspices of the Colonial Governments date, speaking approximately, from about 1858, a date which closely coincides with that given by Professor Waldo (1860) as marking a definite epoch in the development of the modern science of meteorology. The investigation of the law of storms by Buys Ballot, Dove, and others, and the researches of Ferrel, then just commenced, on the theory of atmospheric motions, cleared the way to further advances; and, later on, the utilisation of the electric telegraph, which is to the meteorologist what the telescope is to the astronomer, in extending his field of view over large areas of the earth's surface, enabled the observer to mark and watch the birthplace of storms, track their course and rate of translation. The same means informed him of the general distribution of pressure, and, knowing the laws governing the circulation of air currents round regions of high and low barometers, he soon felt himself justified in issuing warnings of coming gales and the probable state of the weather some hours in advance. He was no longer confined to his own particular locality, laboriously compiling statistics and studying local prognostics; he could look far around

him, see storms a thousand or more miles distant, and tell people with a considerable amount of confidence when they might be expected and what would be their force. This is the great function of modern meteorology. But, like everything else, it took time. It required money from the State, which was not always readily forthcoming; it required, moreover, a complete and extensive organisation of skilled observers, all working on the same lines and with the same objects in view. It had also to win the confidence of a sceptical public, which still placed confidence in quack weather prophets, who, like Moore and Saxby, could tell them what the weather would be all the year through, according to the phases of the moon. Confidence, we are told, is a plant of slow growth. So it is, and so it should be if progress is to be made on a sound, solid, lasting basis.

So long ago as 1854 Admiral Fitzroy advised the Home Government to establish a meteorological office, with a view to the issue of weather forecasts and storm warnings to all the principal ports of the kingdom. This suggestion was ultimately adopted, and a Meteorological Department, under the Board of Trade, was organised, over which Admiral Fitzroy presided until his death, and storm warnings were issued as proposed. Leverrier, at Paris, also commenced the publication of daily weather bulletins.

On the death of Admiral Fitzroy the Government invoked the aid of the Royal Society, which resulted in the appointment of a standing committee to superintend the meteorological work undertaken by the Board of Trade.

The functions of the Committee were divided into three great branches:—

- I. *Ocean Meteorology*.—The object of this branch is to deduce the meteorology of all parts of the ocean from observations made by ships. The surface of the ocean is conventionally portioned off by lines of latitude and longitude into a vast number of sections, and the meteorology of each section is discussed as though it were an independent district. The issue of instruments to ships is also undertaken by this branch.
- II. *Telegraphic Weather Information*.—This branch of the functions of the Committee comes most prominently before the public, but it must not therefore be assumed that it is the most useful or important part of their work.
- III. *Land Meteorology of the British Isles*.—The new feature of this branch consists in the establishment of seven land observatories, provided with self-recording instruments. Its object is twofold: first, to give accurate data for a discussion of the law of storms and weather changes; and, secondly, to ascertain meteorological constants,

thereby performing with great precision for the land stations that which is accomplished with moderate precision by branch I. for the entire ocean.

On the recommendation of the Committee, Mr. R. H. Scott, F.R.S., was appointed director of the meteorological office, Capt. Toynbee, R.N., as marine superintendent, and Mr. Balfour Stewart as director of the Kew Observatory.

Shortly after, the storm warnings, which had been temporarily suspended, were resumed, and daily forecasts have been issued up to the present time with a very fair amount of success. It soon became evident, however, that concerted action to secure uniformity of systems and a more complete organisation was urgently necessary; and, on the invitation of Dr. Bruhns of Leipzig, Dr. Wild of St. Petersburg, and Dr. Jelinck of Vienna, a meeting of meteorologists was convened and held at Leipzig in 1872. The invitation stated that "the development of interest in meteorological investigation in modern times among all civilised nations has brought into prominence a requirement which has long been felt, viz., that of greater uniformity of procedure in different countries." This was followed by congresses at Vienna in 1873, at London in 1874, at Rome in 1879, the last being at Munich in 1891.

In the United States, where they have done more, perhaps, than any other country, a very complete system was organised in charge of the Chief Signal Officer, no expense being spared, and for many years three synoptic weather charts were issued daily.

Turning again to Australia, we found the same need for uniformity and co-operation between the colonies, and, at the instance of Mr. Russell, a conference was held at Sydney in 1879, which was attended by the following delegates:—Mr. Russell, Government Astronomer, New South Wales; Mr. Ellery, Government Astronomer, Victoria; Mr. Todd, Government Astronomer, South Australia; Sir James Hector, K.C.M.G., Inspector of Meteorological Stations, New Zealand.

After discussion the following resolutions were arrived at:—

- I. That, in view of the great importance which a better knowledge of the movement and origin of strong gales and storms on our coastlines and neighboring seas is to the shipping and commercial interest generally, it is desirable to secure, as far as possible, co-operation in all the Australasian Colonies for the investigation of storms, as well as for agricultural and general climatological purposes.
- II. That, with the view of giving effect to the foregoing resolution, similar observations and the same form of publication should, as far as possible, be adopted throughout the colonies.
- III. That, in order effectively to carry out the objects of the Conference, as affirmed in the foregoing resolutions, it is desirable to establish first-class meteorological stations

in certain well-selected positions in the several Australasian Colonies, including New Zealand, in addition to those existing.

- iv. That the definition of the work of a first-class station, given in the preface to the New Zealand Meteorological Report for 1873, be adopted, viz.:—"The observations taken are limited to those for determining atmospheric pressure, maximum and minimum daily temperature of atmosphere, and of insolation and radiation, the average daily amount of moisture, the rainfall and number of rainy days, the force and direction of wind, and amount and character of cloud."
- v. That the instruments at each first class station consist of a mercurial barometer, of either the standard or Board of Trade form; thermometers of new or approved patterns, compared with standards as frequently as possible; rain-gauges of 8 in. collecting diameter, and wind-gauges of any approved form. The local hours of observation to be 9 a.m., 3 p.m., and 9 p.m. Beaufort's scale of wind to be adopted. The observations to be recorded in equivalents and pressure.
- vi. That it is very desirable to obtain the co-operation of the Government of Tasmania, and to persuade them to establish a station at the public expense at Hobart Town.
- vii. That it is desirable to secure the co-operation of the Governments of Western Australia, New Zealand, and Tasmania in the system of weather telegrams, which now embraces the colonies of South Australia, Victoria, New South Wales, and Queensland.
- viii. That, in the opinion of this Conference, it is desirable that weather telegrams and forecasts shall, in all cases, depend upon the observations used for general meteorological and climatological statistics, and be under the direction of the head of the meteorological department in each colony.
- ix. That this Conference, having been informed that the Eastern Extension Telegraph Company will charge half rates for the transmission of weather reports through the cable connecting Australia and Tasmania, and probably also the cable to New Zealand, recommend that the cost of such reports be defrayed by the participating colonies in equal proportions; and that, in the opinion of this Conference, such cost need not exceed in the aggregate £350 per annum.
- x. That, in the opinion of the Conference, this expenditure is justified by the extreme importance to the shipping interest of early information of the approach of dangerous easterly and westerly gales.

- C S. aspect West Cape to Moeraki.
 D S.E. aspect Moeraki to East Cape (exclusive of Cook Straits).
 E Cook Straits.... Comprising Wanganui, Wellington, Cape Campbell, and Cape Farewell, Nelson.

A code to be framed to express the weather in each of above aspects in general terms, according to the judgment of the reporter, thus:—

Aspect.	Wind and Weather.	Rain.	Sea.
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No remark to indicate absence of phenomena.

- xvii. That the telegrams furnished to Melbourne by Tasmania should conform with those between the Australian Colonies.
- xviii. (1) That weather telegrams from the Australian Colonies shall comprise:—
1. Barometer reduced to 32° F. and sea-level
 2. Dry bulb
 3. Humidity
 4. Maximum and minimum
 5. Direction and velocity of wind
 6. State of weather
 7. Rainfall
 8. Sea disturbances,
- with a synoptical report of the weather generally.
- (2) And that within New Zealand the same system should be adopted.
- xix. That the extreme importance of the weather system proposed be strongly urged upon the Queensland Government, with a view to obtain their more active co-operation.
- xx. That Australia be divided into six meteorological areas for transmission of reports to New Zealand, viz., Western Australia, South Australia, Victoria, New South Wales, and Queensland; South Australia being divided into two districts, tropical and extra-tropical.
- xxi. That weather telegrams be written on paper of a special color, so as to be readily distinguishable in the offices.
- xxii. That the solar radiation thermometers should be blackened bulb thermometers in vacuo, and should be exposed on an open space at an elevation of 4ft. 6in. from the surface of the ground, supported by a post carrying two light arms.
- xxiii. That radiation thermometers be placed over grass.

xxiv. That the following subjects for experiment be referred to each member of the Conference, for future consideration and report:—

1. Shade temperature.
2. Swinging thermometer and thermometer sheds in use.
3. Standards to be swung with 2ft. 6in. string during sunshine and after sunset.
4. Observations to determine the difference in humidity, by self-registering maximum and minimum thermometers, and by other methods.
5. The best method of measuring the velocity and pressure of wind.
6. Whether any better method than black bulb thermometers can be devised for measuring the direct effect of the sun.
7. As to the best method of determining spontaneous evaporation.

xxv. That, as investigation of the Newcastle tide-gauges has shown that such instruments give valuable indications of distant earthquakes, gales, and sea disturbances, it is desirable, in the opinion of the Conference, that self-registering tide-gauges be established in as many convenient places as possible on the coast, in connection with the meteorological departments of the different colonies.

xxvi. That the foregoing minutes be adopted as the report of this Conference on the various matters referred to it, and that the chairman be requested to report to the Government of New South Wales.

A second conference was held at Melbourne in April, 1881, the same gentlemen being present. Among other resolutions, it was agreed—

That daily isobar maps, on the system adopted in Europe and America, should be issued by the head office in each colony.

That, with a view to the instrumental readings being referred to one uniform standard, a complete set of standard instruments, viz., barometer, thermometer, solar thermometer, and anemometer, be purchased for circulation between the then four chief stations, viz., Melbourne, Sydney, Wellington, and Adelaide.

That the New South Wales Government should move the Queensland Government to co-operate by transmitting daily reports from Brisbane, Rockhampton, Cooktown, Normanston, and Cloncurry.

The Governments of New Caledonia and Fiji were also to be moved to have regular observations taken and published, on the Australian system.

A third conference was held at Melbourne in September, 1888, at which all the colonies were represented:—Mr. Ellery, Victoria; Mr. Russell, New South Wales; Sir James Hector, K.C.M.G., New Zealand; Mr. C. L. Wragge, Queensland; Sir John Forrest, K.C.M.G., Western Australia; Captain Shortt, Tasmania; Mr. Todd, South Australia.

A number of important subjects were discussed at this Conference, which I need not here particularly specify.

Amongst other things it was agreed—Mr. Wragge dissenting—that each head office should restrict its forecast, as a rule, to its own colony, and that the colonies should exchange their forecasts by telegraph, so that they might be published in a complete form in the daily papers.

The object of the Conference in arriving at this decision was to secure the publication of the local forecasts at the earliest possible hour; and, further, to avoid the issue of conflicting forecasts, which it was thought would confuse the public, and create a want of confidence in the system.

I may say here that, in Adelaide, we publish our forecasts for South Australia shortly after 1 p.m., in time for insertion in the afternoon papers, frequently including the forecasts for Victoria and New South Wales, supplied by Mr. Ellery and Mr. Russell. The forecasts, which apply to the twenty-four hours ending at 6 p.m. on the following day, and a short description of the weather generally, are posted in the hall of the General Post Office, at Port Adelaide, Largs Bay, and several other ports and towns in the colony.

As the outcome of these conferences we now have a daily (Sundays excepted) interchange of weather telegrams between all the Australian Colonies, including Tasmania and New Zealand.

In all there are about eighty selected reporting stations, besides which nearly every telegraph station reports at 9h. a.m. to the head office the direction of the wind, the state of the weather, and the rainfall, which are also posted in a collective form at the General Post Office for public information.

From these data isobar and weather charts are compiled in nearly all the colonies, together with the forecasts to which I have referred.

At Adelaide, where, as I have already said, we have issued daily isobar maps since 1882, we exhibit a diagram showing the barometric curve at selected stations along the south coastline from Albany to Cape Howe during the month, which enables persons to see at a glance the westerly progressive march of coastal depressions; and we have recently added a map which shows the distribution of rain in the colony on each wet day.

We also publish monthly a statement of the rainfall at every station throughout the colony, compared with the average of the corresponding month deduced from previous years, accompanied

by a complete discussion of the characteristics of the month in regard to temperature, pressure, the passage of "highs" and "lows," and the weather generally, in which comparisons are made between the month under review and previous seasons, attention being drawn to any abnormal features that may have presented themselves.

The annual volumes give in detail the observations at Adelaide, the principal results at outstations, and maps showing in graduated tints the general distribution of rainfall during the year.

An examination of the daily isobar maps extending over a period of eleven years shows that, while we have an infinite variety of details, there are several well-marked types which are frequently recurring.

No two maps of the same type, perhaps, may exactly agree or resemble each other, but the type to which they belong is at once recognised. We can thus classify our maps into their respective types.

I have selected seven well-marked types to accompany this paper (see Plate VI.).

MAP No. 1—FEBRUARY 18TH, 1890,

Shows the ordinary summer high pressure over the south coast, having its maximum about latitude 45° , which is further south than usual, covering Tasmania, with gradual falling gradients northwards to the usual low pressure conditions of the tropics.

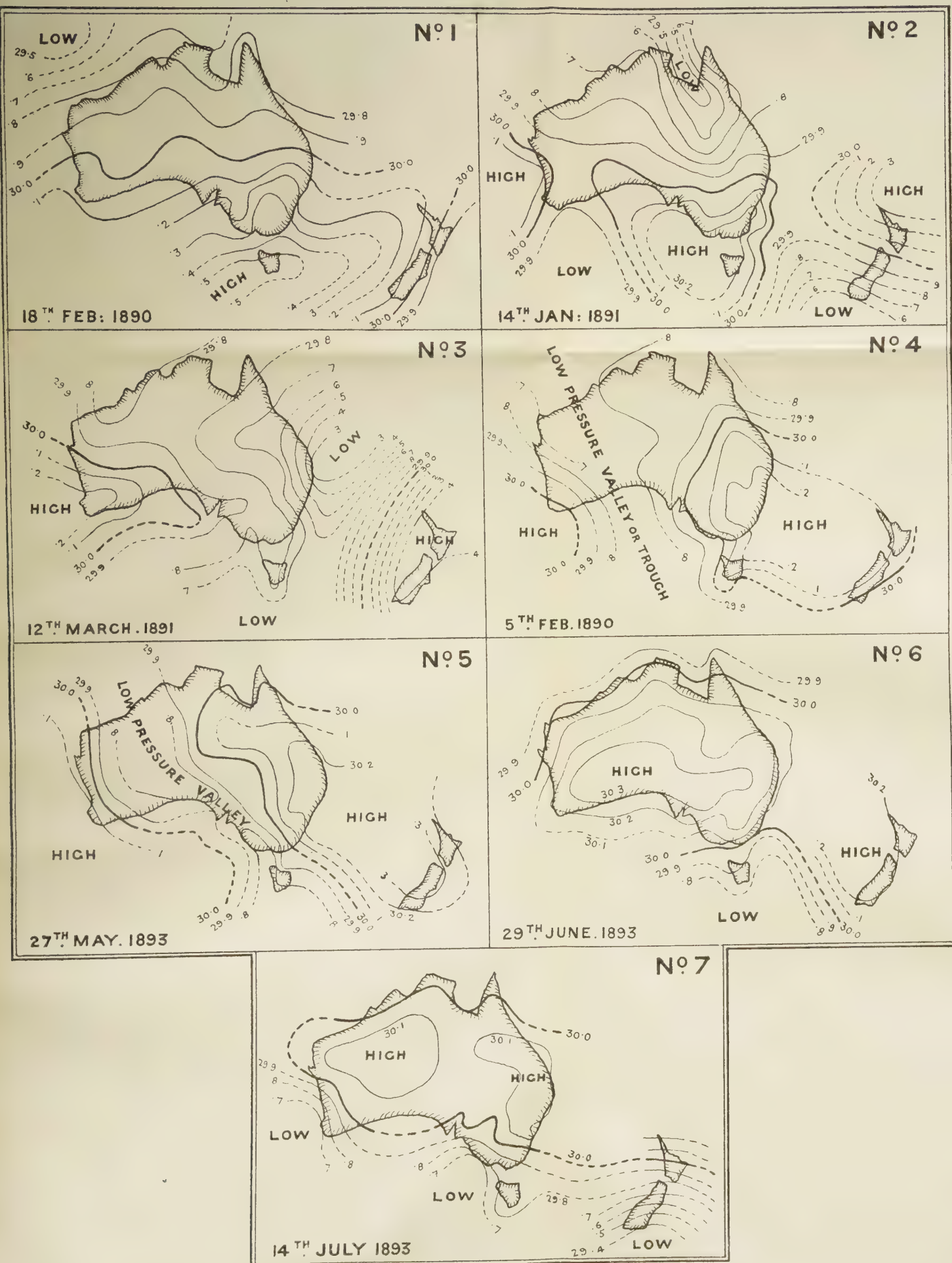
The map indicates a cyclonic centre to the north-west of Australia, where the barque *Dorunda* reports the barometer down to 29.47, in longitude 114° E. and latitude 15° S.

This cyclone was moving westward when encountered by the *Dorunda*, and probably passed through the S.E. trade belt; then recurring to the eastward, may possibly be identical with a south coast depression which appeared off the Leeuwin on the morning of the 24th, but if so it had greatly lost its energy.

The weather corresponding to this map was—Fine, except on and near the east coast from Cape Howe to the Gulf of Carpentaria, where the weather was everywhere cloudy and unsettled, with rain, heavy rains falling on the coast. Over the whole of Australia the winds were south-east, and strong from the east through Bass's Straits.

Following, we had general and heavy continuous rains for several days in both Queensland and New South Wales, the isobar charts showing a V-shaped depression gradually extending southward into Queensland from the Gulf of Carpentaria, whilst the high pressure to the south became split up into two parts by a northerly low pressure extension towards our south coast. In Queensland and northern New South Wales many heavy floods were reported, Townsville (Queensland) having over 19in. of rain in three days.

SYNOPTIC WEATHER CHARTS FOR AUSTRALASIA



MAP No. 2—JANUARY 14TH, 1891,

Shows a tropical "low" in the Gulf of Carpentaria, working its way southwards over Queensland, whilst to the south is a "high," having its maximum, 30·2 in., over Tasmania, the south coast of Victoria, and part of New South Wales between two "lows," one approaching from the west and south of the Leeuwin, and the other to the east, covering southern New Zealand.

With this map we had fine weather over Tasmania, Victoria, South Australia, and Western Australia; cloudy to gloomy and very unsettled throughout Queensland and New South Wales, with rain, very heavy in former colony.

Subsequent weather.—The "low" shown over the gulf country of Queensland passed slowly southwards, and on the morning of the 17th lay over the Riverina districts of New South Wales. Very heavy and general rains continued all over the eastern colonies, and heavy floods resulted in many parts of Queensland and New South Wales, and stormy conditions affected the east coastline. The "high" shown off the south coast moved eastward, as the "low" worked its way southward from northern Queensland.

MAP No. 3—MARCH 12TH, 1891,

Is a very important type. It shows a tropical cyclonic "low" approaching the east coast between Sydney and Brisbane from the north-east—a not infrequent occurrence in the summer. A "high" lies to the south-east, with compact gradients, the maximum pressure, about 30·4, embracing the whole of New Zealand.

Another "high" is seen pushing its way over Western Australia, whilst a "low" lies to the south of Victoria.

This map and No. 2 deserve careful study, as the conditions they indicate affect largely the weather on the east coast of Queensland and New South Wales generally, bringing heavy flood rains in both colonies, the rains frequently extending well into the interior, occasionally reaching the north-eastern districts of South Australia.

In this instance the weather was stormy, with heavy seas and strong southerly gales along the New South Wales and South Queensland coasts; fine inland and throughout all southern, central, and western Australia, with some cloud along the coast between Kangaroo Island and the Leeuwin.

The first indications we had of the approach of this disturbance was on the morning of the 7th, when the barometer on the Queensland coast commenced to fall, with freshening south and south-east winds. By the morning of the 13th it had become merged into the low pressure waves shown off Tasmania, and passed south of New Zealand during the following night. The weather, as it progressed, was very coarse and bad on the east coast, with heavy rains; but the rains were confined to the coastal districts, and the reports on the 14th show heavy weather to the

south of New Zealand, with strong south-west gales. Two days after this, the "high" shown on the map of the 12th to the westward of Perth had moved eastward and covered the whole continent, with its centre (30.45) off Kangaroo Island (S.A.).

MAP No. 4, FEBRUARY 5TH, 1890, AND MAP No 5, MAY 27TH, 1893. Show low pressure valleys stretching across the continent connecting the tropical and south low pressure belts. These are frequently productive of good general rains; the winds on the east side of the trough are northerly, and southerly on the west side—strong if the valley is narrow and nipped up between two "highs" with steep gradients on either side.

With No. 4 map the weather was cloudy and unsettled in the rear or west side of the low pressure trough, with showers all along the coastline of Western Australia: in advance of the low pressure valley it was partially clouded in central and north Australia, gloomy and sultry in South Australia with steady rain falling over the northern areas, very hot (95° at Eucla) over the head of the Great Australian Bight, fine and warm in Victoria and Tasmania, cloudy in eastern Queensland and north-east parts of New South Wales, and thundery in Central Queensland.

The maps for the previous day or two show that the formation of the valley of low barometers was preceded by a general taking off of pressure over the interior of Western Australia on the 3rd.

Next morning, the 4th, the valley was very well defined, the weather chart for that date being almost identically the same as that on the 5th. Splendid general rains set in over South Australia during the afternoon and evening of the 4th, extending from Strangways Springs to the Mount Lofty Ranges. Subsequent maps show that as the isobars moved eastward the low pressure valley or trough underwent considerable modification, though the valley-like depression was clearly marked in each map.

The heavy steady rains which fell in advance of the valley in South Australia did not, however, extend to the eastern colonies, and its effect on the weather in New South Wales and Victoria was to produce sultry and oppressive conditions, which culminated later on in heavy thunderstorms and rains over a large part of both colonies.

The weather with No. 5 map was cloudy to gloomy in southern West Australia, with heavy showers on south coast, fine and clear in the north. All over South Australia (nearly across the continent), Victoria, Tasmania, and the western half of New South Wales it was cloudy to gloomy, and threatening with rain falling in the northern areas of South Australia, and in places in the other colonies; in Queensland fine but cloudy.

This map shows a slightly different trough formation to No. 4. In the latter the valley ran north and south across Australia. In this the axis lies north-west and south-east.

The maps immediately preceding the 27th show an ordinary low pressure wave advancing eastwards along the Southern Ocean, with a "high" over the continent, gradually retreating before it to the eastwards. On the 26th signs of a valley forming were very marked, and on the next day we have the trough shown in map No. 5.

The subsequent weather charts are very interesting. The 28th being a Sunday no chart was issued, but on the 29th we find that a well-marked cyclonic depression had developed over South Australia, the centre lying between Adelaide and Port Augusta, and the Barrier Ranges in New South Wales, whilst a large high pressure area lay over New Zealand and the ocean between those islands and the Australian coast, and another "high" overlapped the south-western portion of the continent. This low pressure centre then passed southwards to between Kangaroo Island and Lacepede Bay, thence down the coast over Tasmania, and off towards New Zealand.

Splendid rains fell all over this colony, Victoria, and Tasmania, extending well inland over the north-east districts of South Australia into western and central Queensland. In South Australia it was one of the heaviest, if not the heaviest, general rainstorm of which we have records. The bulk of the rain fell between 9 a.m. on the 27th and 9 a.m. on the 30th, and during that period we find that in South Australia heavy rains fell everywhere south of Alice Springs; in New South Wales light to heavy rains fell almost generally; also in Queensland, especially in the centre and west; whilst in Victoria and Tasmania there was a copious rainfall throughout.

I doubt if so extensive a rainstorm has been experienced since records began. The drought over our north-eastern country, western and central Queensland, was broken up, and practically more than half the entire continent participated in the downpour, which was certainly as beneficial as it was extensive.

MAP No. 6, JUNE 22ND, 1893,

Is a typical winter map, an anticyclonic area resting over the interior, with its maximum extending from the Great Australian Bight to the centre of the continent, and in a long loop from Western Australia to near the coast range in Queensland, whilst over the Southern Ocean we have the usual low pressure belt.

The weather was mostly fine and clear in Western Australia; in South Australia dry south-east winds were blowing in the interior from Lake Eyre to the north coast, and the weather was cloudy fine to gloomy, and in parts foggy, with misty rain over southern districts. On the Victorian coast it was cloudy and showery, and fine and clear inland there and in New South Wales; fine but more or less cloudy in Queensland and the Northern Territory. There were frosts in early morning in Victoria and southern Queensland.

Subsequent maps show that the "high" gradually increased in energy till the 1st of July; then decreased slightly during the next day or two, the centre of the anticyclone remaining stationary over the southern part of South Australia. Very cold frosty nights were experienced inland over South Australia and New South Wales, the thermometer on grass at the Sydney Observatory on the morning of the 4th reading 24° —the lowest reading there in thirty-five years.

MAP No. 7, JULY 14TH, 1893,

Is another typical winter map showing an extended series of low pressure waves passing in rapid succession easterly along the south coast—one rounding the Leeuwin, another to the west of Tasmania, while a third is over southern New Zealand, with its centre to the south of the island. A moderate "high" covers Australia from west to east.

The trend of the low pressure isobars on the south coast is a very general feature. Reaching up northwards into Victoria, they curve abruptly southwards, rounding Tasmania to the south, and then recurving northwards up the east coast. In many maps this is much more marked. The same feature may be seen in maps 3 and 6. This abrupt northerly extension east of Tasmania frequently gives rise to strong southerly winds on the New South Wales coast.

The weather was cloudy to threatening and showery in West Australia; cloudy to gloomy and threatening, and in a few places showery, with squalls on coast, in South Australia, Victoria, and Tasmania; fine and clear in north-east New South Wales, unsettled in west: cloudy to gloomy in south and east parts of Queensland, clear in centre and north-west districts.

This map was taken at random from several during a long spell of cyclonic conditions, lasting from the 8th to the 24th, and clearly shows the rapid succession of V-shaped depressions along the south coastlines. With each depression unsettled weather and rain passed along the south coast of the continent. The "low" shown off the Leeuwin when it reached the Bight passed inland over South Australia, causing the rains to be heavier and more general than when the previous depression passed along the south coast further to the south.

Leaving the maps, and speaking generally, I would point out that in both the Northern and Southern Hemispheres is a belt or zone of high pressure, separating the tropical and polar zones of low pressure at the latitude where the return trade and polar winds descend towards the surface of the earth.

The southern belt passes over the extra-tropical or temperate parts of Australia. It is made up of long loops, or anticyclonic areas, being broken up at intervals by low pressure intrusions from the tropics and northerly extensions of V-shaped depressions from the south. When these join they form a barometric trough or valley, effecting a complete rupture of the anticyclonic belt. The position

or latitude of this anticyclonic belt depends on the time of the year, and varies in different years. Normally, during the winter the crest of the "high" lies over the interior, approximately about latitude 29° or 30° (*vide* map 6). North of this the continent is swept by the dry south-east trade winds, whilst to the south we have, in South Australia, a prevalence of dry northerly (north-east to north-west) winds, varied by strong west and south-west winds as coastal depressions pass from west to east, with rain and squally weather. On the east coast west winds prevail during the winter.

The character of our winter season, in South Australia especially, depends very closely on the position of this wall, as it were, of high barometers, which plays a very important part in Australian climate. If it lies too far south, or near the coast, the winter over the southern districts of the colony (I am speaking of South Australia) is dry, but we may, and occasionally do, have under these conditions good rains in the north, due to the extension of tropical depressions bringing rain over the interior of Queensland, New South Wales, and South Australia east of Lake Eyre and the Flinders Range.

On the other hand, if the anticyclonic areas keep more to the north, the southern or coastal V depressions extend further inland, at times being felt as far as the tropics, and we have copious rains all over the colony, as well as in Victoria and western New South Wales. As the depressions pass the winds veer from north-east and north to north-west, west, and south-west. Steady rains set in with the wind at north-east to north, heaviest at north-west, and break up with heavy showers and squalls at south-west, sometimes accompanied by heavy thunderstorms, while the wind is north-west to south-west.

As the summer advances the high pressure belt retreats, and usually lies a little to the south of the coast, with its maximum pressure about latitude 37° to 40° , and the whole of the interior of Australia is then well within the equatorial belt of low pressure.

On the north coast, and for some distance inland, the winds are north-west, monsoonal rains setting in at the end of October and lasting till the end of March or April, the heaviest rain being in December, January, and February, in which months the average at Port Darwin is 10.420, 14.782, and 13.009 inches, respectively.

The southerly reach of the north-west monsoon depends on the pressure in the interior, which is frequently very uniform, but when a barometric valley (*vide* maps 4 and 5) is formed the rains may extend almost without a break right across the continent, being in some years very heavy and general in South Australia. On the east coast summer rains are frequent and heavy, especially when tropical "lows" pass down from the north and north-east (*vide* maps 2 and 3).

In South Australia the prevailing wind in summer is south-east, varied by hot, dry, northerly winds, as coastal "lows" approach

from the west, followed on their retreating side by a sudden shift of wind to south-west and a rapid fall of temperature as the depression passes, the thermometer at times falling 30° or 40° in a few hours. I have known a fall of 20° in almost as many minutes.

From what I have said you will see that we have, as weather conditions :—

- 1st. A continual series of anticyclonic areas, which in the winter pass over the interior, covering the whole or greater part of the continent, with gradual falling gradients from the centre, while in the summer they pass along or near the south coast.
- 2nd. Cyclones, disturbers of the peace, but bringing fruitful rains; sometimes, alas! disastrous floods. These are mostly of tropical origin, and, starting on a west to south-west course, they re-curve south of the trade belt, and move to the south-east. Some—those approaching from the north-east of Australia—strike the east coast of Queensland; others enter by the Gulf of Carpentaria, and, passing inland, shed rains over the western interior of Queensland and New South Wales; others pass over the interior from the north-west; whilst others again pass to the west of Australia, and ultimately, rounding the Leeuwin, appear as a south coastal disturbance.
- 3rd. Northerly extensions of the antarctic low pressure, which, passing along the south coast, give us our winter rains, and, on their retreating side, south-westerly gales.

Taking the five years 1888 to 1892, Mr. Russell, in a recent paper to the Royal British Meteorological Society, states that on the average about forty-three high pressure areas pass over us during the year, and that they are more frequent in summer than in winter.

Their general movement, as with cyclones, is from west to east, curving to the south-east, no doubt dying out as they reach higher latitudes. Mr. Russell makes their average rate of motion to be about 400 miles a day, passing over Australia in seven or eight days in summer and nine or ten in winter. My own observations lead me to the conclusion that anticyclonic areas seldom retain their general outlines and energy for any great length of time; both are continually varying, according to surrounding conditions. For instance, our weather charts may show an anticyclone on the west coast pushing its way inland, and in a few days covering nearly the whole of the continent; but by that time it will very frequently have greatly increased in energy, and the central pressure may be $30\cdot5$ in. or more, although no such pressure may have passed over the west coast: it gets built up over the land. This is especially noticeable when there is a deep "low" adjoining, say, off the coast to the south-east, the increased pressure in the anticyclone being probably due to the upper outflow of air from the neighboring "low," or cyclone.

An anticyclone is fitful and uncertain in its movements; it may remain stationary, or nearly so, over the interior for days together, and then suddenly split up, or contract, or show diminished pressure; and then, perhaps, make a rapid forward move, and again come to a standstill, after which it will pass off to the south-east and in a few days appear over New Zealand. The movements of cyclonic areas are more marked and regular, though by no means uniform. Taking the south coastal depressions, of which about sixty pass during the year, I find they travel on the average at the rate of 25 miles an hour.

Over the United States the average is about 28·4 miles, ranging from 34·2 in February to 22·6 in August. Over the Atlantic in middle latitudes the average is 18 miles, ranging from 20 in November to 15·8 in July. Over Europe the average is 16·7, ranging from 19 in October to 14 miles in August.

The progress of our south coastal depressions is frequently retarded by anticyclonic conditions ahead or to the east of them, which will sometimes deflect them such a distance to the south as to barely affect the weather in this colony. In other cases, after pushing up into the Great Australian Bight, or near Eucla, as a well-marked V, they will, more particularly during the winter, open out and the isobars will run roughly parallel with the coast (or east and west), and we have then long shoots of north-west and west winds, with either no rain or squally showers on the Mount Lofty Ranges and the coast, and fresh westerly winds with rain through Bass's Straits. All these conditions have to be taken into account in framing our daily forecasts. Taking the last four years, the forecasts issued in South Australia have been justified to the extent of 73 per cent., partially justified 20 per cent., and wholly wrong 7 per cent. In connection with this work, I have much pleasure in acknowledging the great and zealous assistance I receive from Mr. Griffiths. Our usual practice is for Mr. Griffiths and myself each to write out independently a forecast. The two are then compared, and adopted if they agree. If they disagree we discuss the conditions very carefully, and decide what the forecast shall be. In my absence this work entirely devolves on Mr. Griffiths.

SEASONAL FORECASTS.

The importance to the farmer, the horticulturist, and pastoralist of knowing beforehand the probabilities of dry or wet winter seasons, and whether the rains will be early or late, or both, has naturally led to a desire for seasonal forecasts. They have them, it is said, in India; why not in Australia?

A letter from Mr. Archibald, at one time on the meteorological staff in India, published in Queensland, opened the ball. As the responsibility of issuing such forecasts would not devolve upon himself, he was, perhaps, the more fearless in suggesting what should be done by others. The Postmaster-General of Queensland,

the Hon. Mr. Unmack, expressed a desire that the matter should be discussed at the recent Brisbane Postal and Telegraph Conference, and for this purpose Mr. Russell, and Mr. Ellery, and myself were invited to meet Mr. Wragge. I think we all felt that it was altogether premature to attempt anything of the kind, at all events for the present, and the suggested conference of meteorologists fell through. However desirable such seasonal forecasts may be, to be of any practical value they must be reliable, or at least so far generally verified by the results as to secure the confidence of the community. Frequent or even occasional failure would bring the system into contempt, and do far more harm than good. We have had instances of rashness in the prediction of droughts, which very seriously depreciated property, and we should move cautiously where so many interests are affected. Meteorology is still far from being an exact science, and the phenomena presented to us are so complex as to render the prediction of the weather even a few days in advance very often a matter of considerable difficulty. I have always regarded what we are doing as paving the way to further extensions of the system, with a view to the forecasts covering longer periods. This, however, can only be done by the accumulation and intelligent discussion of the necessary data, and the correlation of weather conditions over considerable areas of the earth's surface. I have already made some attempts to do this, but much remains to be done.

I may, perhaps, add that, so far as I know, India is the only country which has attempted anything like a systematic issue of seasonal forecasts. These are mainly based on the amount of snow falling during the previous winter on the Himalayas, and the general character of the weather in India during the five or six months preceding the setting in of the south-west monsoon; the chief objects of the forecasts being to give some idea of the probable rainfall during the ensuing monsoon.

DROUGHTS.

Australia, lying between the parallels of 11° and 39° S. has a tropical and sub-tropical climate, with monsoon summer rains on the north coast and winter rains on the south coast, both extending well inland. A great part—all the interior—is within the anti-cyclonic region of high pressure and dry south-east winds; it is therefore subject to severe droughts, more or less prolonged. The driest portion appears to be a belt of country reaching from north of the Great Bight and Lake Eyre, or about lat. 30° , to near the north-west coast, which is swept nearly throughout the year by the south-east trade. The climate of the eastern half of the continent is more favorable, as the monsoonal rains extend further south over the coastal ranges, which form the watershed of the large rivers and watercourses running through the interior on the one side, and to the coast on the other.

With regard to the winter rainfall in South Australia, our records appear to show—

1. That in the thirteen years when the mean summer pressure was *above* the average and the temperature *below*, the following winter rain was *below* the average in nine years, *above* the average in only one year, and *about* an average in three years :
2. That in the nine years when the summer pressure was *below* the average and the temperature *above*, the following winter rain was *above* the average in seven years, *below* in only one year, and *an average* in one year :

From which we obtain the following general rough rule :—

Summer *cool*, with *high* barometer : winter *dry*.

Summer *hot*, with *low* barometer : winter *wet*.

As regards the future, if I may venture to make any suggestions, it appears to be desirable that the meteorological observations of the different colonies should be published in a more uniform and systematic manner, in such complete detail as will assist theoretical deductions, and be accompanied by fuller discussion of results, general character of the weather, storms, extent and duration of droughts, and any abnormal conditions that may have occurred during the year. Mr. Russell has done very much in the latter direction in his publications on the climate of New South Wales, and rains, and state of rivers, &c.

We also require normal isobaric and isothermic maps for each month and the year, but the observations as at present published hardly afford sufficient data for these, and many of the stations have been too recently established to furnish more than roughly approximate averages.

New Caledonia would be a valuable reporting station in regard to cyclones approaching the Queensland coast from the east, and I trust the cable now laid will be utilised as early as possible. I would also strongly urge an exchange, by mail, of weather charts and observations with the Cape of Good Hope, Natal, and Mauritius.

CONCLUSION.

I feel that I have trespassed too long on your time, but I have had a considerable stretch of ground to cover. The record I have placed before you—very imperfectly, I fear—is one of which we have have no need to be ashamed. That meteorology should have been taken up so energetically and been so liberally supported by the several Colonial Governments, on whose purse, in building up a new nation, there are so many claims, is not, however, without a sufficient cause. To successfully occupy and establish industries in new countries, a knowledge of climate and the meteorological conditions under which we are to labor is essential to success, as teaching us what we can best and most profitably produce. Situated within and without the tropics, with such a range of

climate, from the snows of Kosciusko to the burning plains of the interior and the humid heat of Port Darwin, we can obtain nearly all that man requires. Our marvellous growth in the past is only a foretaste of the future, and under such sunny skies we should be, as I trust we are, in spite of the clouds of depression which occasionally hang over us—with, however, silver linings not far away—a happy and contented people. The lines have fallen to us in pleasant places, and truly we have a goodly heritage.



4.—SOME OF THE DIFFICULTIES OF OBTAINING EXACT MEASUREMENTS IN ASTRONOMY.

By W. E. COOKE, M.A., Adelaide Observatory.

[ABSTRACT.]

These refer to—1st, nadir point; 2nd, effect of temperature upon a micrometer; 3rd, determination of co-latitude; 4th, instrumental flexure; and 5th, refraction.

1st. The old forms of mercury trough (non-amalgamated) fail to give satisfactory images of the wires, but this difficulty has been partially overcome by amalgamating the sides and bottom of the trough. The nadir point is subject (at Adelaide) to two kinds of variations, viz., a change in short periods of time, or during a night's observing, evidently depending upon local variations of temperature; and an irregular, but, on the whole, progressive change from day to day, especially noticeable during the summer months.

2nd. The nadir point reading changes whilst the observer is simply standing near the micrometer, and if the observer stand on the same side of the instrument the change is always in the same direction. During an hour's observing of stars, all of which are on the same side of the zenith, the nadir point alters by as much (sometimes) as $2\cdot5''$, and it invariably increases whilst observing stars on one side of the zenith and decreases for stars on the other. It seems necessary, therefore, to take at least two nadir point readings during each evening's work.

3rd. The latitude obtained for the same place with the same instrument varies from year to year, and this sometimes to an extent which cannot be explained by Chandler's periodical "variation in latitude." I cannot suggest any direct remedy for this, but perhaps close attention to the other points raised may indicate a method of obtaining this important constant with greater exactness.

4th. The flexure of the transit circle varies from time to time, and its law does not seem to be satisfactorily determined. A correction of the form $f \sin. Z.D.$ gives apparently the best results, and the quantity f (horizontal flexure) ought to be determined once a week at least, or probably with greater frequency. The

correction to *Z.P.* obtained from the reflections of stars is very unsatisfactory, and there are grounds for believing that it is time to discontinue the "double observation" of a star, and to adopt some other method of reflection observation. Sir Charles Todd proposes to select groups of stars, of which one (A) will be observed directly, and another (B) by reflection, on one night, whilst on the next B will be observed directly and A by reflection. This will eliminate any error due to comparatively violent usage which a telescope must experience when a star is observed both directly and by reflection on the same evening.

5th. The law of, and the mean, refractions are not yet definitely settled. It would be well if all astronomers were to agree upon a form of thermometer exposure, and if two or three northern and southern observatories were to take a set of stars selected so as to decide these points as far as possible.



5.—EARTHQUAKE INTENSITY IN AUSTRALASIA:

WITH A FEW REMARKS ON THE TASMANIAN EARTHQUAKES,
SUGGESTED BY THE DIAGRAM OF INTENSITY.

By *GEORGE HOGBEN, M.A., Timaru, N.Z., Secretary Seismological Committee, A.A.A.S.*

PLATE VII.

Dr. Edward S. Holden, Director of the Lick Observatory, in a paper entitled "Earthquake Intensity in San Francisco" (*American Journal of Science*, June, 1888), has given the equivalents of the degrees of intensity of earthquake shocks on the Rossi-Forel scale, in terms of the acceleration due to the velocity of the shock itself, expressed in millimetres per second. These equivalents are:—

Rossi-Forel Scale.	Intensity in Millimetres per Sec.
I.	20
II.	40
III.	60
IV.	80
V.	110
VI.	150
VII.	300
VIII.	500
IX.	1,200

The absolute scale is calculated, on the assumption that earthquake motion does not differ greatly from simple harmonic, by means of the formula—

$$I = \frac{V^2}{a} = \frac{4\pi^2 a}{T^2}$$

where a = amplitude of largest wave, T = its period, V = velocity of impulse given by the shock, and I = intensity of shock, or destructive effect, defined mechanically as = maximum acceleration due to the impulse. a and T are taken from the records of twenty-one carefully selected earthquakes in Japan, for which these elements were observed by Ewing, Milne, and Sekiya. The determination is possibly the best possible at present, and forms the basis of the remarks in this paper.

I. *New Zealand*.—For New Zealand we have, for the years 1848-92, the records of 926 earthquake shocks; but in the earlier years only the severest shocks were recorded, and until December 1889, when the present system of observation through the officers of the Telegraph Department was begun, most of the shocks of intensity I.-III. were probably neglected. Now I am convinced, however, that comparatively few shocks pass unnoticed; those that do would be all, or nearly all, of the degree I. or II., on the Rossi-Forel scale. As there is such a difference in the quality of the records, we shall get the best estimate of the average intensity of shock in New Zealand by taking only recent years into account. I have therefore based my calculations on the records of the three years 1890-92.

The following table shows the number of shocks in each year, classified according to intensity, and the total intensity in absolute units:—

EARTHQUAKE SHOCKS IN NEW ZEALAND, 1890-92.

Intensity.		Number of Shocks Recorded.				Total Intensity in Millimetres per Sec.
Rossi-Forel Scale.	Milli- metres per Sec.	1890.	1891.	1892.	Total (3 years).	
I.	20	—	—	—	—	—
II.	40	—	1	8	9	360
II.-III.	50	—	3	6	9	450
III.	60	11	21	45	77	4,620
III.-IV.	70	16	36	4	56	3,920
IV.	80	10	5	5	20	1,600
IV.-V.	95	2	—	3	5	475
V.	110	5	2	1	8	880
V.-VI.	130	—	—	1	1	130
VI.	150	3	1	1	5	750
VI.-VII.	225	—	—	3	3	675
VII.	300	—	1	3	4	1,200
VII.-VIII.	400	—	1	—	1	400
		47	71	80	198	15,460

Average maximum intensity of shock 78.

The average maximum intensity is 78 millimetres per second, or a little less than IV.

In every case where an earthquake was observed at more than one place, I have taken the estimate of intensity where the shock was most severe. If we were to take the lowest estimate of intensity, we should get about 66 millimetres per second for the average intensity of shock. The mean of these is 72 millimetres per second; * that is to say, the average intensity of shocks as *felt* in New Zealand is between III. and IV. on the Rossi-Forel scale, or sufficient to make pictures move a little, and to cause some doors and windows to creak or rattle slightly.

The total maximum intensity for three years is 15,460 units, or 1.576 times the acceleration due to gravity (which = 9,810 units per second). If the force of the 198 shocks were concentrated into one, each earth-particle would receive an impulse of a little over 50ft. per second.

New South Wales, Victoria, and South Australia.—As in the case of New Zealand before the adoption of the present system, the severer shocks were noted and nearly all those of lower intensity were not observed, or at least not recorded. From the catalogue of earthquakes published in the last report of the Seismological Committee† we can construct the following table, which may be taken for what it is worth:—

	Length of the Record.	Total No. of Shocks.	Average of Shocks per Year.	Total Intensity of all the shocks.	Average Intensity of Shock. Maximum Value.	Average Intensity of Shock. Minimum Value.	Mean Average Intensity of Shock.
	Years.			In millimetres.		Per second.	
New South Wales	12	24	2	2,270	94.6	75	84.8
Victoria	8	61	7.6	5,200	85.2	73.2	79.2
South Australia..	10	81	8.1	5,525	68.2	59.3	63.8

In New South Wales and Victoria the average intensity of shock is certainly one degree too high; but in South Australia, where the records seem to have been more complete, the estimate is lower, and probably not very far from the truth. The average maximum intensity of shock is between III. and IV., and the mean average intensity of shocks as felt in South Australia about III., or sufficient to be felt by several persons at rest, and for the duration or the direction to be appreciable.

Tasmania.—The records for Tasmania consist chiefly of those for the remarkable series of shocks felt in that colony in the years 1883-86. Soon after these shocks began, Captain Shortt commenced a regular system of recording the observations made at

* These figures would of course all be reduced if we could include the shocks below III., which generally escape notice. † Transactions, A.A.A.S., 1892.

the various meteorological stations, principally in the north and north-east of Tasmania and on the islands between Tasmania and the mainland. For this purpose he issued instructions to the various observers as to the consistent use of the adjectives "very slight," "slight," "heavy" or "severe," and "very severe." In a large number of instances sufficient details are given to enable me, especially after discussing the matter with Captain Shortt, to assign values, on the Rossi-Forel scale, to each of his adjectives.

The result of the steps taken is a most valuable catalogue of the shocks. Unfortunately the time observations were not exact enough, except in one or two cases, to enable us to ascertain the origin thereby; but an earthquake that occurred on the 27th January, 1892, can be referred to a definite origin; and I hope to examine many of the shocks of the years 1883-6 as to the possibility of their having come from the same spot.

The table appended gives the number of shocks for each month from April, 1883, to December, 1886, arranged according to intensity, on the Rossi-Forel scale, and the total intensity per month in absolute units.

[NOTE.—It will be observed that no shocks are classed as IV. This does not mean that no shocks of that intensity were felt, but indicates some difficulty in assigning the exact degree for a large number of shocks between III. and V. I tried several hypotheses agreeing with the available evidence, but all came to nearly the same result, namely, that there were 2,210 shocks varying from III. to V., and their total intensity was a little less than 160,000 units. The shocks that might therefore be classed as IV. are put down as III. or V., according as the evidence inclines to one or the other degree of the scale.]

The total number of shocks for the forty-five months was 2,540, an average of 56·4 per month, which would be sufficiently startling were it not that the average intensity of shock was only between III. and IV. One month—October, 1883—enjoys the questionable distinction of having 231 shocks recorded against it, that is, seven or eight shocks a day; and November of the same year is not far behind. The total intensity was 186,690 units, or about nineteen times acceleration due to gravity, which gives an average intensity per shock of 73·5 millimetres per second. If all this were concentrated into one instant it would give an impulse of 612ft. per second.

[The minimum value assignable for the average intensity of shock is 68·3, a figure that allows also for the possibilities of error introduced by classifying shocks of intensity IV. as III. or V. The mean of 73·5 and 68·3 is 70·9 units, which we may take to be the average intensity of the shocks felt.]

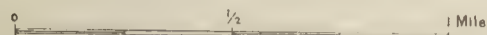
The diagram accompanying this paper (Plate VII.) shows, in a graphical form, the history of the series of shocks; the ordinate of any point on the curve shows the total intensity per month in

GEOLOGICAL MAP

SHOWING

GLACIAL DRIFT, W. OF BACCHUS MARSH.

Scale—Two Inches to a Mile.



- GROOVES AND STRIÆ. ○ GRAPTOLITES. ○ GANAMOPTERIS.
- MIOCENE LEAF AND FRUIT CASTS. ⊕ SCHIZONEURA. ○ CYCADS, &c.
- + GOLD. — FAULT.
- GRANITE. SILURIAN. GLACIAL DRIFT.
- G. S. G.D. 1. CONGLOMERATE.
- M. G.D. 2. SANDSTONES.
- G.D. 3. MUDSTONES.
- MIocene. OLDER BASALT.
- M. NV NEUER VOL. PP POST PLOCENE. ELVAN AND BASALTIC DYKES.

Lines of Sections A-B, C-D, E-F, G-H, I-K, L-M.

C. H. H. H. H. H.

absolute units. The diagram shows very clearly—(1) the rapid rise to the first maximum in October and November, 1883; (2) a second maximum in August 1884; (3) a very gradual decline for nearly two and a half years, the shocks slowly dying away at the end of 1886.

Four of these shocks reached the intensity VII. on the Rossi-Forel scale; for these Mr. A. B. Biggs and Captain Shortt assigned approximate origins. I have also tried to use the available data to ascertain the epicentrum or epicentra; but only in one case is the conclusion at all definite—in the case of the shock-earthquake of the 13th of May, 1885:—Its epicentrum is either identical with or not far from that of an earthquake already referred to, January 27th, 1892, which I have discussed in another paper. For the present I assume that all the important shocks proceeded from the same region, east of Tasmania, about 353 miles from Launceston and 365 miles from Hobart, nearly in the middle of a deep depression in the bed of the Tasman sea. An examination of the records, however, shows that the majority of shocks were felt at one place only (or at two places near together); even when slight they were generally distinct in character, and the rumbling was often of such a nature as to suggest that the cause of it was comparatively near. Hence I conclude that there were constantly going on a large number of smaller movements in the crust of the earth immediately beneath Tasmania and Bass's Strait, which were secondary to greater movements which took place about an axis, or about a point in the deep sea. For three or four years a readjustment of some kind was going on; the larger shocks were perhaps merely incidents caused by movements a little quicker than usual, or by the sudden slipping of large masses out of the position of unstable equilibrium into which the slow movements had brought them.

If these large or primary movements were fault-movements, one would almost expect to find the axis on the edge and not in the middle (or at the bottom) of a steep declivity in the ocean bed. If the primary movement was one of revolution (principally) about the axis, interrupted by an occasional sliding of the mass on one side of the axis upon the mass on the other side, then we must look for secondary movements at some distance from the axis, where the displacement caused by revolution is greater. Is it possible that the lesser shocks were more or less local movements of this character?

Is there any evidence of fault-movements having taken place in Tasmania within the period of these shocks; or any evidence of a change of the level of the land in Tasmania, or in S.E. Australia, or in the islands between them? If such evidence exists, I should be glad to hear of it; but, till it is forthcoming, it would be vain to theorise any more.*

* Any such information may be addressed to G. Hogben, Timaru, N.Z.

The large expenditure of energy implied by the total intensity of the series of earthquakes suggests at least a possibility of a very appreciable amount of movement of the land-mass of Tasmania and S.E. Australia, either upwards or downwards. One does not like to think of mother earth wasting so much of her strength for nothing.

EARTHQUAKE SHOCKS IN TASMANIA, APRIL, 1883, TO DECEMBER, 1886.

Classified according to Intensity on the Rossi-Forel Scale, with the Total Intensity per Month, expressed in terms of the acceleration due to Velocity of Shock.

	Intensity.—Rossi-Forel Scale.					Total No. of Shocks.	Total Intensity per Month in Millimetres per Sec.
	II.-III.	III.	V.	VI.	VII.		
1883.							
April	—	3	1	—	—	4	290
May	1	3	1	—	—	5	340
June	—	21	4	6	—	31	2,600
July	18	46	11	4	—	79	5,470
August	44	32	15	6	—	97	6,670
September.....	43	102	53	4	—	202	14,700
October	3	173	41	14	—	231	17,130
November	7	151	45	18	—	221	17,060
December	9	97	26	11	—	143	10,780
1884.							
January	2	124	37	6	—	169	12,510
February	1	94	17	5	—	117	8,310
March	—	71	12	4	—	87	6,180
April	11	80	22	9	—	122	9,120
May	2	96	17	3	1	119	8,480
June	15	98	25	5	—	143	10,130
July	12	97	23	4	1	137	9,850
August	10	110	39	5	—	164	12,140
September.....	7	70	17	2	1	97	7,020
October	5	40	5	—	—	50	3,200
November	5	12	10	—	—	27	2,070
December	—	18	12	2	—	32	2,700
1885.							
January.....	3	15	16	2	—	36	3,110
February	2	15	2	1	—	20	1,220
March	2	18	9	—	—	29	2,170
April	—	9	7	—	—	16	1,310
May	3	12	5	—	1	21	1,720
June	—	10	2	—	—	12	820
July	1	15	4	1	—	21	1,540
August	—	4	6	—	—	10	900
September.....	—	13	1	—	—	14	890
October	1	4	7	—	—	12	1,060
November	1	6	1	—	—	8	520
December	—	6	1	—	—	7	470

Earthquake Shocks in Tasmania, April, 1883, to December, 1886—continued.

	Intensity.—Rossi-Forel Scale.					Total No. of Shocks.	Total Intensity per Month in Millimetres per Sec.
	II.-III.	III.	V.	VI.	VII.		
1886.							
January	—	1	3	—	—	4	390
February	—	1	—	—	—	1	60
March	—	1	1	—	—	2	170
April	—	4	—	1	—	5	390
May	—	2	1	—	—	3	230
June	3	6	1	—	—	10	620
July	—	2	—	—	—	2	120
August	—	2	1	—	—	3	230
September	2	7	4	—	—	13	960
October	—	4	—	—	—	4	240
November	—	5	4	—	—	9	740
December	—	1	—	—	—	1	60
Total for 45 months	213	1,701	509	113	4	2,540	186,690

Average intensity of shock = 73.5 millimetres per sec.



6.—ORIGIN OF EARTHQUAKE OF 27TH JANUARY, 1892 (AUSTRALIA AND TASMANIA).

By G. HOGGEN, M.A.



7.—THE TIDES OF PORT ADELAIDE.

By R. W. CHAPMAN, M.A., and Captain INGLIS.

At the last meeting of the Association in Hobart we presented to the section the results of an harmonic analysis of the curves obtained from the tide gauge at Port Adelaide. This analysis only embraced the short period tidal components. We afterwards extended the computations to include the fortnightly, monthly,

semi-annual, and annual tides, and the complete results we now append in tabular form. The largest of these long period tides we find to be the solar annual, which has a total range of 6in. Next in order comes the solar semi-annual, with a range of 4in. The luni-solar fortnightly comes next with a range of 3in., while the lunar monthly and lunar fortnightly have each a range of just about 2in. We also give a table showing the mean level of the sea at Port Adelaide for each year, and for each month of the year, since 1882. These have been computed from the records of high and low water levels, and show considerable fluctuations in value. The yearly mean has its greatest value (4.291) in 1889, and its least value (4.007) in 1885. The average of the monthly means shows a well-marked yearly tide, but the number of years is of course not sufficiently great to eliminate the effects of the lunar tides. We are now proceeding with a second analysis of the Port Adelaide curves, and this time have the advantage of the use of the computing apparatus which has been designed by Professor G. H. Darwin. He has very generously sent us the apparatus, and we take this opportunity of acknowledging our obligation.

The average heights of the barometer at Adelaide, for each year under consideration, are appended to the table, and it will be noticed that, as a rule, where the barometer level is high the sea level is low, and *vice versâ*. The barometric mean heights have been obtained from the records of the Adelaide Observatory:—

RESULTS OF THE HARMONIC ANALYSIS OF THE TIDES AT
PORT ADELAIDE (Lat. 34° 51' S., Long. 138° 30' E.)

Initial of Tide.	Name of Tide.	H (Mean Semi-range in feet.)	K.
			°
S ₁	Solar diurnal	·077	122
S ₂	Solar semi-diurnal	1·664	180
S ₄	Solar quarter-diurnal	·018	—
M ₁	Lunar diurnal	·011	204
M ₂	Lunar semi-diurnal	1·709	121
M ₄	Lunar quarter-diurnal	·024	—
K ₁	Luni-solar diurnal (declinational)...	·836	231
K ₂	Luni-solar semi-diurnal (declinational)	·469	177
O	Lunar declinational diurnal	·533	34
P	Solar declinational diurnal	·207	231
N	Larger lunar elliptic semi-diurnal...	·076	114
Mm	Lunar monthly	·083	258
Mf	Lunar fortnightly	·081	194
Msf	Luni-solar fortnightly	·133	256
Sa	Solar annual	·248	132
Ssa	Solar semi-annual	·174	304

MEAN LEVEL OF THE SEA AT PORT ADELAIDE FOR TEN YEARS ENDING DECEMBER, 1891.

	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	Sum.	Mean.
January	4·209	3·781	4·225	3·932	4·801	4·917	4·129	4·202	3·717	4·417	42·330	4·2330
February	3·705	4·054	3·668	3·872	4·302	3·781	4·083	3·757	3·663	3·875	38·760	3·8760
March	3·984	4·095	3·426	4·000	3·832	4·358	3·967	4·082	3·856	4·271	39·871	3·9871
April	4·345	4·358	4·103	3·756	4·165	4·114	3·916	4·043	4·052	4·230	41·082	4·1082
May	4·774	4·629	4·208	4·102	4·387	4·330	4·150	4·267	4·117	4·146	43·110	4·3110
June	4·313	4·717	4·948	4·480	4·176	4·671	4·562	5·110	4·928	4·480	46·385	4·6385
July	4·635	4·282	3·928	4·076	4·017	4·851	4·783	4·194	4·225	4·771	43·762	4·3762
August	4·073	4·452	4·283	4·562	4·542	3·793	4·125	4·557	4·192	4·333	42·912	4·2912
September	4·413	3·694	3·957	3·826	4·284	4·480	3·910	4·380	4·412	4·041	41·397	4·1397
October	3·956	3·940	3·948	3·698	4·292	4·163	3·658	4·389	4·575	3·875	40·494	4·0494
November	3·954	4·051	3·470	3·602	4·233	4·071	3·838	4·114	4·307	3·917	39·557	3·9557
December	3·953	4·479	4·459	4·175	4·013	3·861	3·750	4·392	4·110	4·646	41·638	4·1838
Sum.	50·314	50·532	48·623	48·081	51·044	51·390	48·871	51·487	50·154	51·002	501·498	50·1498
Mean	4·193	4·211	4·052	4·007	4·254	4·282	4·073	4·291	4·179	4·250	41·7915	4·179
Mean height of barometer at Adelaide	30·047	30·060	30·075	30·121	30·075	30·066	30·112	30·058	30·036	30·111	—	—

8.—THE APPLICATION OF MATHEMATICS TO ACTUARIAL SCIENCE.

By JOSEPH J. STUCKEY, M.A.

[ABSTRACT.]

I am very glad that the work of an actuary can now, with any degree of fairness, be classed as a science, and that the certainties of mathematics are applicable to this branch of science, although it deals with such uncertainties as the duration of individual life or of the sickness which anyone will experience during life, the probability that a bachelor of a certain age will marry, the probability of issue, of fires, of accident, of marine disaster, and many others.

The method which I propose to adopt in this paper is to take, first, the most advanced branch of actuarial science, and give the application of mathematics to the various stages in chronological order. This, it is hoped, will be satisfactory, although it takes the various branches of mathematics in very much the inverse order of difficulty.

Life insurance is the most advanced branch of actuarial science, but is still pushing on to greater and greater scientific exactitude. It is the compound growth, first, of our commercial necessities, excited by a love of speculation, and, later, of our progressive civilisation. For the former, rough and ready means of estimation were resorted to; for the latter, a long and elaborate course of progressive investigation was needed. The development has taken some three or four centuries, and has had three phases—The experimental period, the speculative period, and the *period of scientific exactitude*.

It was, we are told, 1721 with which this third period began, though the early specimens of life policies of this period are too like the present fire and marine to have much claim to be scientific. They were for one year at 5 per cent., irrespective of age, and seem to have been taken from the then rate of insurance on ships. This period of scientific exactitude is said to have culminated in 1769, with the advent of the Northampton Table of Mortality, and the coincident work of Dr. Price on "Reversionary Payments, &c."

I imagine I can hardly claim that any great use is made of mathematics in the collection of the statistics of life, age, and death, but I may remark that the imperfection and incompleteness of the statistics so collected has required of the actuary and mathematician two things, at least—the supervision of the collection of new statistics, and the adjustment and graduation of the tables of mortality obtained from those already collected. The bills of mortality, the registers of birth, life, and death, were made for other purposes; but it was early seen that the application of the principles of probability to these bills would enable them to furnish the expectations of life and the values of annuities, assurances, and premiums, at any selected rate of interest. They were for a long time used in their

unadjusted or ungraduated state, and the tables of assurances and premiums on them formed the basis of our numerous life assurance companies for a long period; indeed, some of our existing companies' premiums, and even some of their valuations, are still made by the Carlisle table.

In 1848 was formed the Institute of Actuaries, which is described as a scientific and practical association amongst actuaries, and which had amongst its objects "the development and improvement of the mathematical theories on which the practice of life insurance is based, and the collection and arrangement of data connected with the subjects of the duration of life, health, and finance. . . . The improvement and diffusion of knowledge, and the establishment of correct principles relating to subjects involving monetary considerations, and the doctrine of probability."

In 1863 the institute became convinced that the existing tables of mortality were scarcely sufficiently reliable as bases and tests of the stability of life insurance companies, and that at all events the actual results of the experience of a selected twenty of the old English and Scotch companies would be a valuable help to the actuary. The institute consequently set on foot the collection, classification, arrangement, and adjustment of the results of actually assured lives in these companies. The work occupied ten years, and was completed in 1873, embraced some 160,000 lives, and gave as the result the H_M , H_F , H_{MF} , $H_M^{(5)}$ tables of extremely extensive use to-day.

I notice that again, on June 3rd of this year, 1893, the institute thinks the time has come when a fresh investigation into the mortality amongst assured lives may usefully be entered into, and has started again this arduous piece of work, so that in a few years we may have the up to date experience to help us in our scientific researches.

Whether collected by the actuary or by others, for insurance or other purposes, the question of adjustment or *graduation* of the results next claims the help of mathematics, and that of the higher; if not highest, order; since, as they are to be used as a prediction of the future, a basis for contracts to be completed thirty, fifty years hence, a graduation or adjustment to make them what they would have been if extended over a larger number of years, larger and more varied area of country, or a larger population, or number of lives, becomes not only allowable, but absolutely necessary. With a view to graduation, and of saving the enormous labor involved in the calculation of annuities, &c., specially those on several lives, various efforts have been made to put into a mathematical formula the

LAW OF MORTALITY.

All these efforts have a very distinct scientific basis, and have produced increasingly useful results to the actuary and the cause of science; but it will probably be necessary now only to refer to

two. One is that of equal decrements of life in equal times, known as DeMoivres' hypothesis, and the formulæ and tables giving the values of annuities and assurances on one or more lives on this hypothesis have been obtained and calculated. From a mathematical point of view these formulæ are simple, and the calculations of the annuities and assurances are for several lives comparatively easy. It is therefore to be regretted that the hypothesis is very far removed from the truth, so that these formulæ and tables are practically useless; as, if you take any of the tables—as Northampton, Carlisle, or indeed any table of actual results of duration of life—you will see that the decrements of life are anything but equal.

These decrements of life are now known as d_x , *i.e.*, the number who die between age x and $x + 1$, and just as these decrements are the first differences of the column l_x , the number alive at age x , so they in turn may be differenced so that DeMoivres' hypothesis is that the second differences vanish and the first are constant. Although this is not true in any true table, yet if the second and subsequent differences, whether positive or negative if only small, be taken out, some of the advantages of the simplicity of the DeMoivres' formulæ may be retained. I can here speak of my own knowledge, having differenced out the H_M table to the fifth difference, and the Carlisle to the fourth, one starting with 100,000 lives, and the other with 6,460 at age 10, and have used these differences to construct the C, D, M, N, R, and S columns for each table. The late Peter Gray gives a mode of constructing the D column given C, and while not knowing his mode I had extended it to the construction of the C column which involves d_x , or the first difference from a column we may call C'_x , including the smaller numbers of the second difference, and these again from, say, C''_x , involving the third difference, and so on. This I regard as a good mode of constructing the C and D columns to a large number of places of decimals, or even to the usual six or seven figures, more especially as the M, N, R, and S columns are easily obtained at the same time.

It may be remembered that these C, D, M, N, R, and S columns are the commutation columns, and that $a_x A_x$, the annuity and assurance on life, aged x , are given by the formulæ—

$$a_x = \frac{N_x}{D_x} \quad A_x = \frac{M_x}{D_x}$$

while the R and S columns are needed for the values of increasing annuities and assurances.

The only other attempt, and it is a brilliant one, to obtain the law of mortality to which I shall refer is that of Benjamin Gompertz. His principles seem to be that "death may be the consequence of two generally co-existing causes, the one chance without, *i.e.*, independently of any previous disposition to death or

deterioration, the other a deterioration, or an increased inability to withstand destruction." The formula given by Gompertz is an exponential one, viz. :—

$$l_x = k (g)^{q^x}$$

which gives for the "force of mortality"

$$\mu_x = B q^x$$

that is, the values of the force of mortality at successive ages form a geometrical series.

These formulæ of Gompertz, by assigning suitable values to the constants, k , g , q , represent the results of observations for a series of consecutive ages for about thirty years, but require the introduction of new sets of constants at certain periods of life to complete the table of mortality. The modification of Makeham on these formulæ is—

$$l_x = k a^{-x} (g)^{q^x}$$

whence

$$\mu_x = A + B q^x$$

A few words from Gompertz's writing show that the hypothesis itself was derived from an analysis of the experience disclosed in various published tables of mortality, so that he would seem to have taken the observed results, and thence, by the differential and integral calculus, derived the philosophical hypothesis already referred to. Makeham's modification is, we are told, really included in the two suppositions or conclusions of Gompertz—the one being reproduced in the A of the μ_x and the other in the $B q^x$. We are also told that Makeham's modification, with only one change of constants for the childhood ages, will hold good for the whole term of life.

We are now ready to consider the question of *graduation* of mortality tables—that is, to modify and adjust the actual results, so as to make them reliable for future probable experience. I can only indicate some of the various methods—

1. Woolhouse's, which seems to be to take the number living at any age of the unadjusted data for intervals of five years, commencing at 10, 11, 12, 13, 14, to interpolate by finite differences for the intermediate ages, thereby producing, so to say, five curves of life. The arithmetical mean of the ordinates of these five curves is at each age then taken as the adjusted number living at that age.
2. The graphic method, which appears now to be championed mostly by Mr. Sprague, and which appears to be to plot the values of the function to be graduated by means of abscissæ and ordinates as points in a curve, and then by the eye and hand to draw a curve which shall, to the best of the operator's judgment, make a smooth and even representation of the original facts, or as they would be if due weight were given to all and the effects of further data duly allowed for.

3. Mr. Makeham, as may be supposed, graduates by his modification of Gompertz's law.
4. Mr. McKay's method claims to allow for the weight of observations, and seems also based on some modification of Gompertz's law.

After the adjusted table of mortality is obtained the calculation of the annuities, assurances, and premiums at various rates of interest becomes principally a numerical task in which the actuary is aided by logarithms—ordinary and Gaussian—by tables of interest, and by the help of the calculating machine, the arithmometer.

There seems now little diversity of opinion that the method of *commutation columns* is the best for obtaining the annuities, premiums, and assurances, whether of, for, or on single or several lives or survivorships, and they also give the simplest formulæ for short-term assurances, for increasing or diminishing assurances, annuities, or premiums, return of premiums, endowments, endowment assurances, &c.

For several lives these calculations become long and troublesome, and here the use of Gompertz's law (where applicable) very much reduces the tables to be calculated, and, where not applicable, the approximate formulæ given by the application of the differential and integral calculus for questions involving more than two lives become indispensable. Possibly the simplest case of the use of these commutation columns, *i.e.*, a single life, may not be out of place —

$$D_x = l_x v^x \quad N_x = \Sigma D_{x+1}$$

v being the present value of £1 due one year hence.

$$C_x = d_x v^{x+1} \quad M_x = \Sigma C_x$$

$$\pi_x, \text{ the annual premium, } = \frac{M_x}{N_{x-1}}.$$

In chronological order, the next point where mathematics meet the actuary is in the valuation of the assets and liabilities of a company, and ascertaining the profits or loss, and allocating (in a mutual company) the bonuses. This, too, is best effected by the commutation columns, or by the annuities deduced therefrom; for instance, the best whole life formula is now considered to be

$${}_nV_x = 1 - \frac{1 + a_{x+n}}{1 + a_x}$$

Here, too, the question of *interpolation* comes in, to avoid the necessity of separate calculation of each value required of premiums or what not, but every, say, fifth or tenth value is calculated, and then the others are interpolated by the formulæ derived from finite differences of which those proceeding by central differences are probably the best. *Conic sections*, and its extensions also here find a place, as we find the actuaries now interpolating by means of what they call the quartic parabola, whose equation appears to be

$$y = ax + b x^2 + c x^3 + d x^4$$

and is spoken of as the curve of constant fourth differences. From this, by the differential calculus, and that of finite differences, other formulæ for interpolation are obtained.

In quitting, for this present purpose, the branch of life insurance, I may remark that these mathematical niceties and absolute formulæ added to the mercantile reserves and precautions render a policy on one's life in a good office, spite of the uncertainty of life, one of the most certain things in the world.

I class *Friendly Societies* as the next branch of actuarial science where mathematics are applicable. As the question of sickness incapacitating from work is now involved, as well as that of death, one is sorry that, though they have more need, they have made less use of the certainties and formulæ of science. The principle of the sickness question is that the society receives so much a week from the member during life, or up to a certain age, and undertakes to pay him a certain amount a week when too ill to work. This sick pay is often diminished after the first six months of sickness. Again the same processes have to be gone through, and first the collection of statistics. Here these are done by the societies, or the larger associations, comprising many societies, such as the Oddfellows, Rechabites, Foresters, &c. Then these are adjusted by the actuary by some of the previous methods, and when adjusted, commutation columns, including now additional columns for each class of sickness, first six months, second six months, and subsequently, are constructed, and from them the present value of the sick pay is formed.

Their assets and liabilities, and their financial position, are also valued by similar methods to those indicated for life companies.

I hope that these societies will soon pass into the stage of scientific exactitude, as there is no reason why the weekly contributions should not bear a strictly mathematical relation to the sick pay to be received. It will be seen, therefore, that sickness matters are considerably behind life ones in scientific exactitude; for while, as regards both the mathematical theory and the data to which it can be applied, the science of life contingencies may now be said to be nearly perfect, the extension of these principles to the work of friendly societies is still in its infancy.

Insurances against Issue are effected by a good many companies, and to apply the science to these matters we require a combined marriage and mortality table, and to be able to answer such questions as—What is the probability that a bachelor of a given age will (1) marry, or (2) die unmarried in an assigned year from the present time, or (3) be alive and still unmarried after the lapse of a given number of years; and some progress has been made in the collection of statistics, graduation, &c.; also in the preparation of such a table with the value of monetary benefits dependent thereon. Similar to these may be mentioned the question of *family annuities*, which are spoken of quite recently as a very important and difficult element in some of the State insurance schemes which have lately

been put forward, *i.e.*, the provision of a small annuity to each child of a deceased father until the child attain the age of say twelve or fourteen years. The factors in the calculation are (1) the probability that at the moment of death of a male he is a married man, *i.e.*, a husband or widower, (2) the value at the moment of death of a married man of an annuity to each of his children, (3) the probability of death at a given moment of age, and (4) the rate of interest. The speaker I refer to starts off with the formula—

$$B_x = \frac{1}{l_x} \int_0^{\infty} v^t l_{x+t} \mu_{x+t} (pm)_{x+t} (fa)_{x+t} dt$$

and breaking up this into its component parts he proceeds to discuss, discover, and use from various parts of the world the statistics necessary for the purpose, taking the "orphanhood of children" from our own colony of New Zealand, where the Government Actuary, Mr. F. W. Frankland, secured that the registrars should ascertain and record the numbers, ages, and sex of children left by deceased males. He then proceeds by graduation, where possible, and by commutation columns, to find the value of the benefits concerned.

Accident Insurance appears, as far as I know, to be just peeping over the boundaries of actuarial science with, I hope, longing eyes, and has already received some notice from the institute, as I notice that in 1882 a writer to their journal had collected and partly arranged from various sources the statistics of death from accident from various causes.

These, however, seem insufficient for the mathematician to graduate and for the construction of tables of premiums against death by accident.

Fire Insurance also has, I fear, scarcely begun to claim to be an illustration of the subject of this paper, as the premiums have, as far as I know, no claim to be actuarially or mathematically derived from the value of the risk incurred. The institute, through the contributors to its journal, is not silent on the subject, though the contributions scattered over the last thirty years are few. It does appear strange that fire insurance has never attained to anything like scientific exactitude, by being based on exact statistical details.

Marine Insurance appears to have given one of the first ideas of premiums on life, as we are told that the reason why 5 per cent. was charged on the captain's life was because 5 per cent was charged on the ship. Both were "valued policies," and both were for one year.

We have seen that life insurance has wonderfully advanced in scientific exactitude during the last two centuries, but, from the actuary's point of view, marine insurance is just where it was. I venture to suggest that the same scientific principles which govern life insurance as now conducted would and should be extended to marine insurance.

In closing, I may add that while fire and marine have much actuarial science to learn from life insurance, yet the life insurers have somewhat of importance to learn from the fire and marine insurances. These latter are "valued policies," *i.e.*, the ship or house is insured for its full value—that which will replace it if it is lost. Now, of course no mere money will replace a life lost, but for financial purposes I venture to throw out the hint that a man is worth ten years' purchase, *i.e.*, his life should be insured for ten times as much as he earns by personal exertion. And, lastly, may I express the hope that life insurance may progress still in scientific exactitude, that the other branches may follow in her steps speedily, and that, seeing that the uncertainty of life is reduced to a mathematical certainty by the mathematician, the actuary, and the insurance companies, that it will be much more largely availed of by the general population, and that we shall hear no more of the opposition of science or the aspersions of gambling as regards those matters which are applications of mathematics to actuarial science.



9.—EXPLAINING THE CONSTRUCTION AND USE OF WEIR'S AZIMUTH DIAGRAM.*

By PATRICK WEIR, Master Mariner.

Before proceeding to the principal business of this paper it may be well for me to say a few words regarding the importance to navigators of possessing some simple and inexpensive means of readily ascertaining the true bearing of a celestial body at any time, certain necessary data being available.

It may seem superfluous for me to enlarge on the vital importance of knowing exactly in what direction a vessel is being steered; but I may point out that in these days of record-breaking, when fast steamers, to render the distance as short as possible, cut close to dangerous corners at full speed and in spite of fog or darkness, accuracy in the adjustment of the compass is of far more importance than was the case a few years ago, and is at the same time more difficult of attainment on account of the universal employment of iron or steel in modern shipbuilding.

As an example of the influence of a steel ship on the magnetic needle, I may mention that in a new vessel the compass has been deflected as much as thirteen points. When we consider that sixteen points is a semicircle, and would be a complete reversal of the needle, it becomes rather rough on the old proverb which says

* Captain Weir's Azimuth Diagram is published with the Admiralty Charts by J. D. Potter, 11, King-street, Tower Hill, London.

something about the needle pointing true to the pole. This, I admit, is an extreme case, but very few iron ship's compasses are less than four or even five points out on some courses.

I need scarcely mention that vessels are not allowed to proceed to sea with their compasses in this condition. The Board of Trade insists on their being compensated, within manageable limits, by means of magnets suitably placed; and the ability to properly and intelligently manipulate these correcting magnets constitutes a very important element in the qualification of a shipmaster or officer. But it is almost impossible to so adjust a compass that it will be correct under all circumstances; the varying influence of the earth's magnetism, the heeling of the vessel, shifting of masses of iron on board, and various other causes, combine to interfere with its correct action, and the only safeguards are constant watchfulness and frequent correction.

As an instance of the numerous and unexpected dangers which threaten the compass, I may mention the case of a vessel which came under my notice. The iron mainyard of this vessel was simply an enormous magnet, and according to whether the port or starboard yardarm was nearer the standard compass, distant perhaps 60ft., the north pole of the needle was attracted or repelled about half a point, making a total error on swinging the yard of a full point.

The usual method of ascertaining the error of a compass is by comparison of the true bearing of an object with its bearing by compass, and the difference between these two bearings will be the error of the compass for that position of the ship's head. In port or when near the land it is generally possible to work by the true bearing of a fixed object on shore, such as a chimney, tower, flag-staff, &c., and this is the method adopted by professional adjusters. At sea, however, with no land in sight, the only available method is by comparison of the true bearing of a celestial body with its bearing by compass, and the object of my diagram is to facilitate the computation of the true bearing of such bodies as are generally used for this purpose.

In all well-regulated ships the sun's bearing by compass is noted every time that he can be observed rising or setting, and this, compared with his true amplitude by calculation, gives a very handy and correct method of ascertaining the error of the compass. Few parts of the world are, however, blessed with such a clear atmosphere as we have in South Australia, and in many places it is seldom that the exact moment of the sun's rising or setting can be observed. It is also very often desirable to ascertain the error of the compass at other times than when the sun is on the horizon, and during the day the only available means is by comparison of the sun's true azimuth with his bearing by compass.

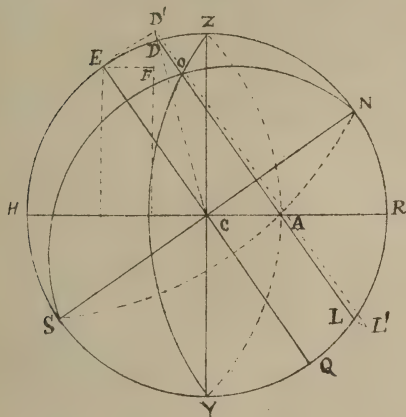
I may here say, though in future I will only mention the sun, that all statements apply equally to any celestial body whose declination is not more than 60° .

The sun's true azimuth or bearing may be computed from either of two sets of data, which can be readily obtained at sea—first, from the latitude of the ship and the declination and altitude of the sun; or, second, from the latitude, declination, and hour angle of the sun, or time from noon (apparent time). In the first case, when the sun's compass bearing is taken, his altitude must be observed simultaneously by sextant or other means; while, in the second case, it is only necessary to note the *time* at which the bearing was taken, as shown on the ship's clock, which is always kept at apparent time, making allowance, of course, for any difference of longitude in the ship's position since the clock was set. This second case (known amongst navigators as a time azimuth) is generally employed on account of its convenience, and it is to facilitate the computation of the sun's true azimuth by this method that the diagram is especially intended, although both cases can with equal ease be solved by it.

I will now proceed to explain, as clearly and briefly as I am able, the train of reasoning by which I succeeded in constructing the diagram, and trust that I may succeed in making my explanation intelligible to the members.

In the natural projection, Fig. 1., suppose the observer to be placed at C in the centre of the sphere; then let H R represent the horizon, N S a line passing through the poles, E Q the equator,

FIG. 1.



Z the zenith, and Y the nadir, E D the declination, D L a small circle parallel to the equator, O the position of a celestial object, N O S a meridian, and Z O Y a vertical or azimuth circle.

In computing a time azimuth, we have given in the spherical triangle OZN the side ON = the polar distance or complement of declination, the side ZN = the complement of the latitude, and the angle ZNO = the hour

angle, to find the angle OZN = the azimuth, which, it will be evident to anyone acquainted with trigonometry, can be done.

The general principles on which I have worked in constructing a diagram to solve this problem were to project the great circle E Q vertically into the plane of the horizon, and, as this is a circle projected obliquely, the resulting projection will be an ellipse,

the semi-major axis of which will be equal to the radius of the circle HR , and the semi-minor axis to the radius $\times \sin ZCE$, which is the sine of the latitude. In the same manner it may be shown that, with any latitude, if the circle representing the equator be projected vertically into the plane of the horizon, its projection will be an ellipse which will have its major and minor axes in the proportion of $1 : \sin \text{latitude}$.

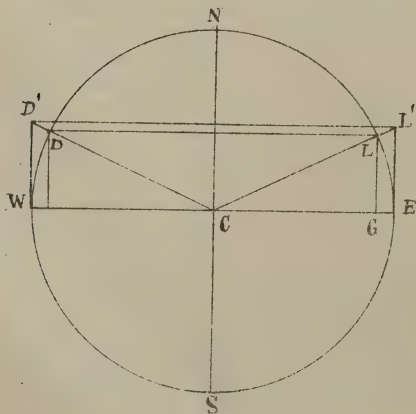
I will now ask the members to imagine two extreme cases. Suppose, in the first place, that an observer is situated at, say, the north pole. From this point of view the sun's path would evidently be a circle, which it would also be according to Fig. 1, because an ellipse whose semi-minor axis is equal to semi-major axis $\times \sin 90^\circ$ would be a circle; and, again, his bearing at any particular time would not be affected by his declination, the altitude only being altered, that is to say, his bearing would be exactly the same at the same hour, say, Greenwich time, all the year round, and of course with any declination.

Suppose, again, that the observer is on the equator and the sun is in declination 0, or also on the equator, it is self-evident that he would rise due east, pass directly overhead, and set due west, so that his path projected on the plane of the horizon would be represented by a straight line, which it would be according to Fig. 1, because with lat. 0 the circle EQ would be projected edgewise.

If the observer were still on the equator and the sun's declination were, say, $20^\circ N.$, his rising amplitude would be $E. 20^\circ N.$ (Fig. 2), meridian zenith distance $20^\circ N.$, and setting amplitude $W. 20^\circ N.$, so that his path might still be represented by a straight line, but distant from the equator by the sine of 20° .

As the sun's path when off the equator is a small circle it would be represented (Fig. 2) by the line DL , which is shorter than the

FIG. 2.

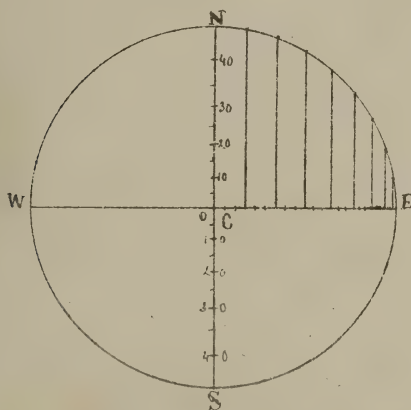


diameter WE , and distant from it by $r \times \sin \text{declination}$.

If, however, it were required to represent the sun's path in different declinations by a line of constant length, as $D'L'$, which is the same length as WE , it would have to be removed from the equator by a distance equal to $r \times \tan$ of the declination in order to make the rising and setting amplitudes work out as by calculation, as can

be seen on Fig. 2 without any explanation. If, therefore, it were necessary, instead of moving the line, to imagine the position of the observer to be shifted in the opposite direction, it is evident that he

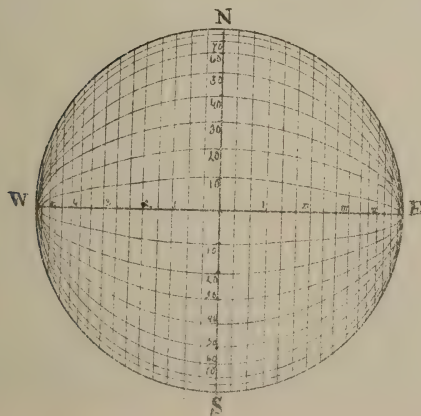
FIG. 3.



the sun's bearing might be calculated at any time, and with any declination, as seen by an observer at the equator.

As I before showed, with the help of Fig. 1, that an ellipse representing the sun's path in any latitude would have its major and minor axes of the same relative dimensions as 1 : sine latitude,

FIG. 4.



would have to be removed to a distance equal to $r \times$ the tangent of the declination. A scale of tangents laid down above and below the equator, as Fig. 3, would therefore represent the position of an observer at the equator for each degree of declination, and if the line C E were divided into a scale of sines representing the sun's position on it for, say every fourth minute of time, we would have a diagram by which

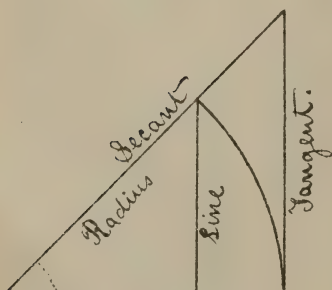
I have constructed a diagram on this principle (Fig. 4), the ellipses being drawn for every tenth degree of latitude, and the position of the sun on them shown for every twenty minutes by the vertical lines. The sun's true azimuth may be taken from this diagram for any latitude and any time as long as his declination is 0° , but if declination be introduced into the problem it becomes more difficult to solve, as I

shall presently endeavor to show. Referring again to Fig. 1; if it were desired to represent the sun's path in any declination by a great circle, that is, a circle of the same size as the equator, instead of a small circle, as shown by D L, it would have to be distant from the equator by $r \times$ tangent declination, as shown by the dotted line D' L', instead of the sine as D L, as is also shown in Fig. 2.

If, however, E Q and D' L' were both projected vertically into the plane of the horizon H R, it is evident that they would not be distant from each other by E D, the tangent of declination, but by E F. But E F is the result of multiplying r tangent declination into cosine latitude. \therefore equal ellipses representing the sun's path on the equator, and his path in any other declination when projected vertically into the plane of the horizon would have their centres distant from each other by the following quantity—(r tangent declination \times cosine latitude). As, however, it is impossible to slide the ellipses along the paper, or even to draw a separate ellipse for each degree of declination, we are reduced to the expedient of supposing the position of the observer to be moved in the opposite direction to an equal distance, that is to say, with north declination he would have to be moved south and *vice versa*, a distance equal to (r tangent declination \times cosine latitude). As this quantity varies with the latitude, a separate scale of declinations would have to be made for each degree of latitude, and though the sun's true bearing in any latitude and with any declination might be taken from a diagram constructed on the principle of Fig. 4, it would be a comparatively complicated operation.

Fig. 4, I may state, was the form in which my first diagram was constructed, and, while experimenting with it, the idea occurred to me that it might be possible, instead of varying the scale of declination for each degree of latitude, to vary the size of the ellipses in, of course, the inverse ratio. I therefore decided, instead of *multiplying* tangent declinations by cosine latitude, to *divide* the major and minor axes of each ellipse by that quantity (cosine

FIG. 5.



latitude). This gives for semi-major axis $r \secant$ latitude and for semi-minor axis $r \frac{\text{sine latitude}}{\text{cosine latitude}} = r$

tangent latitude. It will easily be seen that this preserves the relative lengths of the major and minor axes for any degree of latitude, because $1 : \text{sine} = \text{secant} : \text{tangent}$ (Fig. 5).

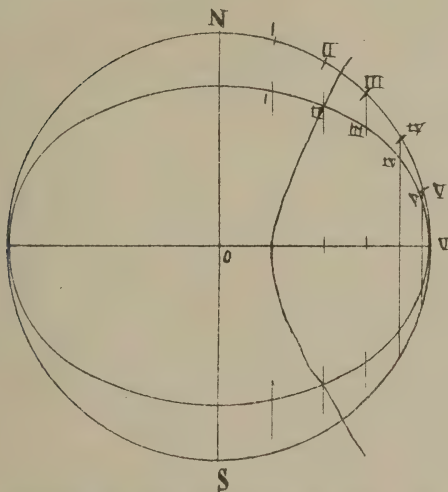
Here occurred a very happy coincidence. In increasing the size of the ellipses the

semi-minor axes, as I have shown, become = tangent latitude, and a scale through which to draw the ellipses will be a scale of tangents laid down on the meridian, but the declination scale is also a scale of tangents along the meridian; therefore both declination and latitude can be measured on the same scale.

Another advantage of this particular proportion of axes (secant and tangent) is that it locates the foci of all the ellipses in the same two points, which was of great assistance to me in constructing my original diagrams with pins and threads.

Having calculated the dimensions of the ellipses and laid them down, the next step is to fix the position of the sun on them for each particular period as minutely as may be required. It is evident that the noon line in all latitudes, and no matter what the declination may be, will correspond with the meridian or minor axes of the ellipses; and it is also equally certain that the six-hour line will be at right angles to the meridian and will correspond with the major axes of all the ellipses, as the sun will just have performed one-quarter of his diurnal revolution at this time. The positions of the intermediate hours, &c., will be simply their positions on a circumscribing circle projected into the ellipse, and may be arrived at as follows:—Take any ellipse of latitude, and with centre O

FIG. 6.



(Fig. 6) and half the major axis of the ellipse as radius, describe a circle about the ellipse; divide this circle into hours, &c., as minutely as may be required, and through these divisions draw lines parallel to the meridian and cutting the ellipse. The point where each cuts the ellipse will indicate the same time as where it cuts the circle. This routine must be gone through for, say, every fifth or tenth degree of

latitude, and when the points so found on the ellipses for each particular period have been joined in a regular sweep they will be found to form a curve which it can be proved is a hyperbola, whose focus is also the foci of all the ellipses.

These hyperbolæ, or time curves, may, however, be described in another and more convenient way by means of a ruler, thread, and pencil, which is, in fact, the usual method of describing a hyperbola. One end of the thread must be fixed in the focus of the hyperbola to be drawn, and one end of the ruler pivoted in the opposite focus; the free end of the thread is made fast to the free end of the ruler. The radius line, that is, the line between the centre of the diagram and the focus of the hyperbola, being laid out in a scale of sines, the length of the thread must be such that the pencil will just be able to touch the sine of the hour for which the hyperbola is to be described. If the ruler be then swung round its pivoted end, the pencil kept close to its edge and the thread extended, the curve described will be a hyperbola, and the point at which it intersects each ellipse of latitude will indicate the position of the sun on that ellipse at the time for which the curve is drawn.

For convenience in measuring off the azimuth I have put a graduated horizon round the margin of the diagram, but any other mechanical means may be substituted.

This completes the diagram as published; and, before complicating it any further, I will explain how it is used for computing a *time azimuth* by reading the description and instructions printed thereon, which description and instructions, I may mention, were written by Sir W. Thomson (now Lord Kelvin), who has taken great interest in the diagram:—"To find the true bearing of a celestial object, the latitude, declination, and time from crossing the meridian (hour angle) being given—

"*Rule.*—Change the signs of both latitude and declination; then from the latitude (on the meridian) follow the ellipse to its point of intersection with the hyperbola of the required hour angle, and mark it; this may be called the *position of the object*. (If the hour angle is less than six hours, this intersection will be on the same side of the equator as the latitude as used on the diagram; if more than six hours, it will be on the opposite side, as the amount over six hours must be measured beyond the equator to obtain the position of the required hour-angle hyperbola). Mark the declination on the meridian; this may be called the *position of the observer*. With the parallel ruler transfer the line joining these positions to the centre \odot of the meridian; the point where the edge of the parallel ruler cuts the graduated horizon is the true bearing, to be reckoned north or south, according as the place where the horizon is cut is north or south of the equator, and east or west, according as the heavenly body is east or west of the meridian."

Although the principal purpose for which the diagram is intended is the computation of a time azimuth, it may be used to solve a variety of other problems, a few of which I now propose to bring under your notice.

Having given the latitude, declination, and hour angle, the true azimuth may be found as I have been endeavoring to explain, but

it is just as simple with *any* three out of these four elements given to find the fourth. Thus, given latitude, declination, and azimuth, the time may be obtained, and so on.

The diagram may be used as a sundial, which will give the correct apparent time at all places on the earth's surface, the latitude being not more than 60° , by placing it horizontally, with its meridian exactly north and south, and erecting a shadow-pin vertically over the declination. Where the shadow thrown by this pin cuts the ellipse corresponding to the latitude of the place will show the apparent time; and, given any three of the four elements mentioned, the fourth may be found by varying the position of the pin, the direction of the meridian, or the ellipse of latitude.

The diagram may also be used to calculate the sun's semi-diurnal arc or time of rising and setting, and, at the same time, his amplitude or bearing when on the horizon, the latitude and declination being given.

Referring to Fig. 1: In the triangle NAR we have given NR =latitude, NA =polar distance, and the right angle NRA , to find AR the cosine amplitude, which, it will at once be evident, can be done. With the same data we can also find the angle ANR , which is the semi-nocturnal arc. I may state that both of these problems can be solved by the diagram in four different ways, but I will not encroach on the time of the meeting by attempting to explain each method, and shall simply try to give an idea of the general principles involved. Find the position of the observer, as explained on the diagram, and, with this point as a centre, describe a circle about the ellipse of latitude and just touching it. This circle will represent the circle of the horizon, and the point where it touches the ellipse of latitude will be the position of the sun when on the horizon. Reference to the nearest time curve will give the semi-diurnal arc; and the bearing from the position of the observer to the position of the sun, taken off in the usual way, will give us his true amplitude or bearing when rising or setting.

As each hyperbola on the diagram intersects each ellipse at right angles, this point (the position of the sun when rising or setting) may be found by using a pair of parallel rulers.

Place the edge of the ruler over the position of the observer, and note which time curve it just touches at the ellipse of latitude; this will be the same point as was previously found, namely, the position of the sun when on the horizon.

In some of my earlier diagrams I laid down another set of lines, which, for want of a better name, I called *rising and setting circles*. They were drawn for each degree of declination up to, say, 30° , and where each curve cut each ellipse of latitude showed the position of the sun when on the horizon at the latitude of the

ellipse, and with the declination of the circle. The method of using them is simply to note where they cut the proper ellipse of latitude, and this will be the position of the body when on the horizon.

The centres of these circles may be found by the following rule:—Subtract twice the declination from 90, and the remainder will be the centre of a circle on the meridian, using the declination scale, radius being equal to the distance from this point to the focus of the diagram. The reasoning by which I arrived at this rule I am not at present prepared to give, but its correctness may be proved in several ways, and it gives the same results as are obtained by calculation. An illustration of its correctness at one point may, however, be given on the diagram itself. If an observer were in latitude 60° S., and a celestial body were in declination 30° S., the body would not set at all, but would simply touch the south point of the horizon and again commence to rise, and similarly at any place where the declination of the body is the complement of the latitude and of the same name it would simply touch the horizon as described; and this, it will be observed, is exactly what happens on the diagram.

In the preceding problems we have again four elements to work with, viz., latitude, declination, time, and bearing; and, given any *two* of these, the other two can be found by the diagram, provided that one of the known quantities is either latitude or declination.

So far it may be observed that I have said nothing about *altitude*, although it plays a very important part in nautical astronomy. The diagram may, however, be used for working out problems in which altitude is one of the elements, by the help of a pair of compasses and scales of cosines, laid down separately. Having found the radius of the circle representing the horizon, with a given latitude and declination, as previously explained, apply it to the scales of cosines, and find with which cosine of 0° it corresponds. The altitude of any point within this circle may be found by measuring its distance from the centre, and this distance applied to the proper scale will give its altitude.

Here we have five elements to work with, viz., latitude, declination, altitude, hour angle, and azimuth; and, given three of these, the other two can be found, provided that either latitude or declination is included amongst the known quantities.

I will not further intrude on the time of the meeting by going into the variety of ways in which the diagram may be used, but will content myself with laying before you a list of problems which I have succeeded in solving by the use of the diagram; and I may mention that there are a few which I have failed to solve, although I have no doubt they can be solved, and probably there are a good many which I have not thought of, but which can be worked out by its use.

CAPTAIN WEIR'S AZIMUTH DIAGRAM.

A List of Problems which can be Solved by its use.

No.	May be Found.	Data Required.	In the Triangle	We have given	To find	Which is
1	Azimuth	Lat, decl., H A.	O Z N	Z N, O N, Z N O	O Z N	Azimuth
2	"	" " alt..	O Z N	Z N, O N, O Z	O Z N	"
3	Hour angle	" " alt..	O Z N	Z N, O N, O Z	N	Hour angle
4	"	" " az. .	O Z N	Z N, O N, Z	N	"
6	Latitude	Decl., H A, az.	O Z N	O N, N, Z	Z N	Co. lat.
7	"	" amp.	N A R	N A, A R, R	N R	Lat.
8	"	" S D, arc .	N A R	N A, N, R	N R	"
9	Declination	Lat., H A, az. .	O Z N	Z N, N, Z	O N	P. distance
10	"	" amp.	N A R	N R, A R, R	N A	"
11	"	" S D, arc .	N A R	N R, N, R	N A	"
12	Amplitude	" decl.	N A R	N R, N A, R	A R	Co. amp.
13	"	" S D, arc .	N A R	N R, N, R	A R	"
14	"	Decl., S D, arc .	N A R	N A, N, R	A R	"
15	Semi-diurnal arc	Lat., decl.	N A R	N R, N A, R	N	S N arc
16	"	" amp.	N A R	N R, A R, R	N	"
17	"	Decl., amp.	N A R	N A, A R, R	N	"
18	Altitude	Lat., decl., H A.	O Z N	Z N, O N, N	Z O	Zen. dist.
19	"	" " az. .	O Z N	Z N, O N, Z	Z O	"



10.—ON STOKES' THEOREM.

By G. FLEURI, Licencié ès-sciences Mathématiques and Licencié ès-sciences Physiques, Sydney, New South Wales.

PLATE VIII.

One of the most interesting questions in mechanics and mathematical physics is the study of the integral

$$\int X dx + Y dy + Z dz$$

where X, Y, and Z are functions of three independent variables x , y , and z , and this study becomes of capital importance when the well-known necessary and sufficient conditions of integrability, *i.e.*,

$$\frac{\partial Y}{\partial x} = \frac{\partial X}{\partial y} \quad \frac{\partial Z}{\partial x} = \frac{\partial X}{\partial z} \quad \frac{\partial Y}{\partial z} = \frac{\partial Z}{\partial y}$$

of function under sign \int are fulfilled.

The first step in connection with that study is to show that the integral round a closed curve is equal to zero, provided that the functions Y, Y, and Z satisfy certain conditions of continuity.

The most satisfying process of demonstration is certainly based upon Stokes' theorem. However—strange enough to say—although the importance of that theorem is everywhere recognised, a correct demonstration of it I have been unable to find.

Analytical transformations either establishing directly Stokes' theorem or deducing it from Green's theorem are easily found, but the difficulty, I think, consists in showing clearly what conditions must be fulfilled by the functions considered to satisfy the theorem.

I propose to give here a complete and correct demonstration of Stokes' theorem, furnishing at the same time a criterion not yet given for the conditions to be satisfied by the closed curve and the functions X , Y , and Z .

I will use, as far as analytical transformations are concerned, a process somewhat similar to the one used by Minchin in his *Statics*.* I will start from the following well-known theorem, which is a particular case of Green's theorem on the transformation of a triple integral.

Theorem.—If U and V are two functions of the real† variables x and y , single valued, and continuous (and consequently finite) within the plane area A (that is to say, for all values of x and y corresponding to points inside A) the double integral

$$\iint \left(\frac{\partial V}{\partial x} - \frac{\partial U}{\partial y} \right) dx dy$$

taken over the whole area A is equal to the value of the simple integral

$$\int V dy + U dx$$

taken along the boundary curve of area A (that is to say, taken in giving successively to x and y all the systems of values which correspond to the different points of the boundary curve) supposed described in such a manner that the area be always kept on the left hand side.‡

Now let us put

$$U = \phi \frac{\partial z}{\partial x}, V = \phi \frac{\partial z}{\partial y}$$

in the expression of that theorem, ϕ being a single-valued and continuous function of x , y and z for every point on a surface

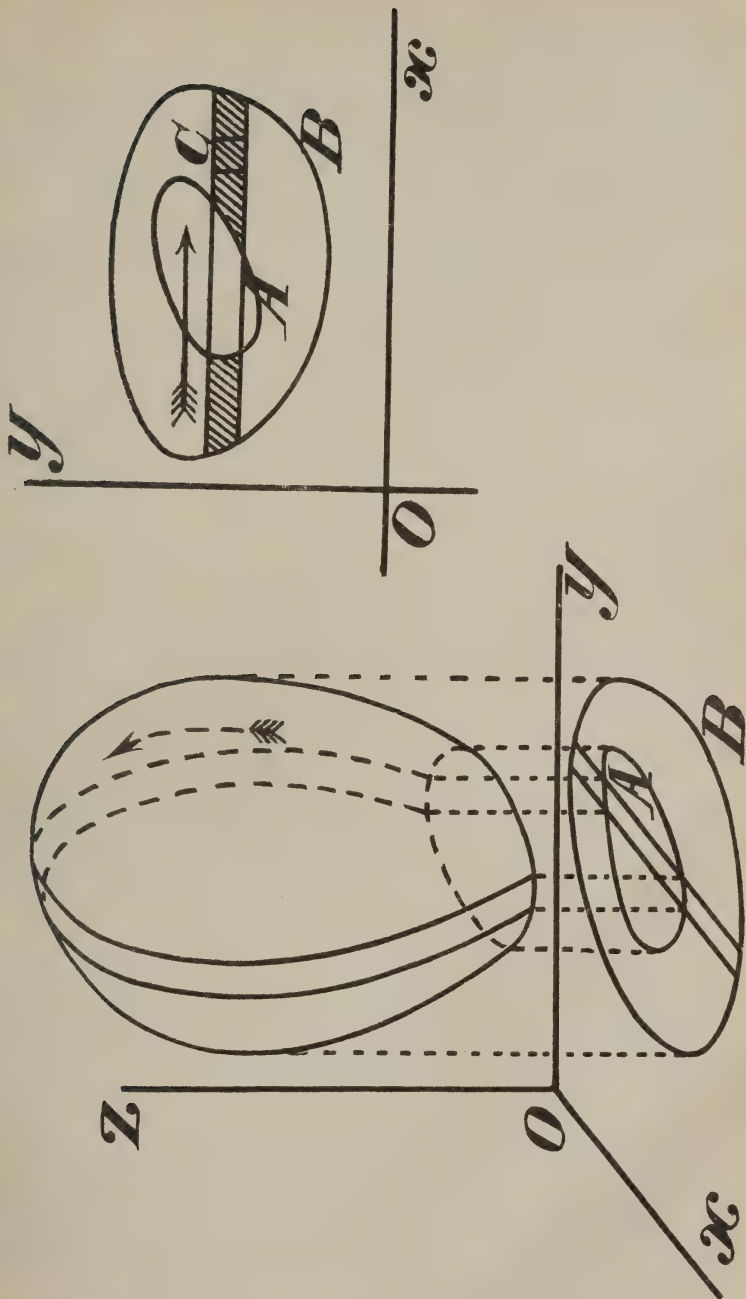
$$(1) \quad z = f(x, y)$$

z being first supposed to be a single-valued function of x and y , or, in geometrical language, any parallel to oz being supposed to meet the surface only at one point, and therefore the projection of the surface on plane xy being then the projection of its bounding edge.

* Minchin: A treatise on Statics, 4th edition, vol. II., pages 242-245.

† The theorem is also true for complex variables.

‡ By replacing V by $U \frac{\partial V}{\partial x}$ and U by $-U \frac{\partial V}{\partial y}$ that particular case of Green's theorem is obtained under the ordinary form.



Thus U and V are single-valued and continuous functions within the plane area A , bounded by the projection of the bounding edge of the surface on plane xy , and we obtain

$$(2) \iint \left(\frac{\partial z}{\partial y} \frac{\partial \phi}{\partial x} - \frac{\partial z}{\partial x} \frac{\partial \phi}{\partial y} \right) dx dy = \int \phi \left(\frac{\partial z}{\partial y} dy + \frac{\partial z}{\partial x} dx \right)$$

But denoting by l, m, n the direction cosines of the normal at x, y, z to surface (1) reckoned in positive direction we have—

$$l = \frac{\frac{\partial z}{\partial x}}{\sqrt{1 + \left(\frac{\partial z}{\partial x}\right)^2 + \left(\frac{\partial z}{\partial y}\right)^2}} = \frac{\frac{\partial z}{\partial x}}{\sqrt{Z}}$$

$$m = \frac{\frac{\partial z}{\partial y}}{\sqrt{Z}} \quad n = \frac{-1}{\sqrt{Z}}$$

and

$$dx dy = n dS = \frac{-1}{\sqrt{Z}} dS$$

Where dS is the element of area at x, y, z of the surface considered. We have besides by differentiation of (1)—

$$\frac{\partial z}{\partial y} dy + \frac{\partial z}{\partial x} dx = dz$$

And now noticing that a passage from one point to another point on the area A corresponds to a passage from a point to another point on surface $z = f(x, y)$, and similarly that a passage from one point to another point on bounding curve of area A corresponds to a passage from one point to another point on the bounding edge of our surface, we can write from (2)—

$$\iint \left(l \frac{\partial \phi}{\partial y} - m \frac{\partial \phi}{\partial x} \right) dS = \int \phi dz$$

where the first integral is to be taken over surface $z = f(x, y)$ and the second one over its bounding edge.

Let us now suppose that z is a many-valued function of x and y , or, in geometrical language, that a parallel to oz meets the surface at several points; then the projection of surface $z = f(x, y)$ on plane xy is no more the projection of its bounding edge, but an other curve, B .

Now let us consider the narrow path determined on the surface by two planes, parallels to xoz , and infinitely near. On the corresponding projection we have an infinitely narrow strip parallel to ox . If we go over the surface along that path always in the same direction—for instance, the direction of the arrow—the corresponding motion on plane xy will consist in:—Starting from A to B ,

then coming back to B, then coming back to A, and so on, so that any infinitely small element of the portion of the strip between A and B (portion shaded on the figure) is gone over n times in one direction and n times in the opposite direction, whilst every infinitely small element of the portion of strip inside A is gone over n times in one direction and $(n-1)$ times in the opposite direction.* Therefore, dividing the surface into slices by planes parallel to xoz , we see that, when we go once over the surface, we go n times in one direction and n times in the opposite direction over every element of area between A and B, whilst we go n times in one direction and $n-1$ times in the opposite direction over every element of area bounded by A.

But as obviously

$$\iint_C = - \iint_{-C}$$

the index indicating that the integral is taken over any element of area C between A and B in one direction and the index $-C$ that the integral is taken over the same element of area C in opposite direction (the same single-valued function being under sign \int) we can replace the double integral of $(^2)$ by

$$\iint \Sigma C - \Sigma C + A$$

that is to say the integral of the same function over elements of C in one direction, over the same elements in the opposite direction, and over A in the standard direction without changing anything.

Applying, then, the same transformation as in the first case

$$\iint \Sigma C - \Sigma C + A$$

becomes, by an appropriate choice of ΣC , an integral all over surface, $z = f(x, y)$, and the theorem is still true.

Now, considering three functions, u, v, w , single-valued and continuous (and therefore finite) of x, y, z , all over a certain surface $f(x, y, z) = 0$ we can write—

$$\iint \left(l \frac{\partial w}{\partial y} - m \frac{\partial w}{\partial x} \right) dS = \int w dz$$

$$\iint \left(m \frac{\partial u}{\partial z} - n \frac{\partial u}{\partial y} \right) dS = \int u dx$$

$$\iint \left(n \frac{\partial v}{\partial u} - l \frac{\partial v}{\partial x} \right) dS = \int v dy$$

where l, m, n , are the direction cosines of normal to surface reckoned in positive direction. And making the sum we obtain—

$$\begin{aligned} \iint \left\{ l \left(\frac{\partial w}{\partial y} - \frac{\partial v}{\partial z} \right) + m \left(\frac{\partial u}{\partial z} - \frac{\partial w}{\partial x} \right) + n \left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y} \right) \right\} dS \\ = \int u dx + v dy + w dz \end{aligned}$$

* It is clear that according to the shape of the surface $z = f(x, y)$ n may vary from one element to another.

That is to say, Stokes' theorem, which is true as long as u, v, w , are *single-valued and continuous functions all over the surface. This is the necessary and sufficient condition.*

Now, coming back to our function—

$$Xdx + Ydy + Zdz$$

supposed integrable, and assuming that X, Y , and Z are single-valued and uniform within a certain region of space, let us consider within the same region a closed curve.

Within that region a surface having the curve as bounding edge can generally be constructed, and, for that surface, Stokes' theorem being applicable gives (taking into account the conditions of integrability)—

$$\oint (Xdx + Ydy + Zdz) = 0$$

the integral being taken along the closed curve.

If the region of space considered is like the inside of a sphere, or like the body bounded by the two sheets of a wave surface (a cyclic region), a surface can always be constructed enclosed by the region, and having as bounding edge any closed curve within that region, so that always in that case

$$\oint X dx + Y dy + Z dz = 0$$

along any closed curve within the region considered; but if the region is like a ring, that is to say, with hole or holes piercing through (cyclic region), such a surface cannot always be constructed for any curve whatever. These curves, which enclose one or several holes, are excepted (irreconcilable curves). Stokes' theorem is no more applicable for them, and therefore for them

$$\oint X dx + Y dy + Z dz \neq 0.$$

Remark.—I have not thought necessary to examine in detail the several demonstrations given of Stokes' theorem, amongst which stand pre-eminent the following, viz.:—Clerk Maxwell (A Treatise on Electricity and Magnetism, th. IV., of preliminary chapter): A demonstration by means of curvilinear co-ordinates. ¶ Thomson and Tait (Natural Philosophy, § 190 (*jj*)). ¶ Tait—On Green's and Other Allied Theorems (Trans. R.S., Edin., 1872, p. 69): This demonstration by means of a network is certainly the best of all. Minchin (Statics, vol. 2)*. A simple comparison with the demonstration I have given will easily show what I intend to criticise.



11.—FROM NUMBER TO QUATERNIONS.

By G. FLEURI, *Licencié ès-sciences Mathématiques and Licencié ès-sciences Physiques.*

* Minchin's demonstrations are remarkable for their inaccuracy. In the theorems 1, 2, and 3, pages 241-245, he does not state a single time what conditions must be fulfilled by his functions ϕ and ψ and u, v, w .

12.—ON MEASUREMENT OF DOUBLE STARS.

By H. C. RUSSELL, C.M.G., B.A., F.R.S.

13.—THERMO-ELECTRIC DIAGRAMS FOR SOME PURE METALS.

By W. HUEY STEELE, M.A.

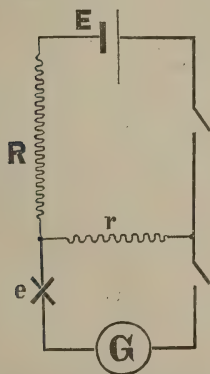
PLATE IX.

The paper by Professor P. G. Tait in the Transactions of the Society of Edinburgh, 1873, "A First Approximation to a Thermo-electric Diagram," has hitherto been admitted to contain the best work done on the thermo-electric diagram. This paper, however, was stated by the author to be merely a preliminary to more accurate results that were to follow, but which have not yet appeared. The paper is mostly taken up with the discussion of the peculiarities in the iron line, and it is not stated whether the metals used were pure or otherwise, what the limits of accuracy of observation were, nor what methods of observation were used. Being in possession of a piece of thallium, whose line was not determined by Professor Tait, I determined its position relatively to silver, in order to determine its position on the diagram, and then, finding its line cutting that of copper at about 70° C. according to Professor Tait's results, I measured its position relatively to copper, and found that the two results were utterly inconsistent, according to Professor Tait's results. On measuring the relative positions of copper and silver, using fairly pure specimens, copper was found to be very close to and above silver, while Professor Tait puts it a considerable distance below. I therefore proceeded to construct the diagram afresh for as many *pure* metals as I could obtain.

The first essential in accurate thermo-electric measurement is a sensitive galvanometer, the one indicating the least current not necessarily being the best for the purpose, but the one that indicates the least current in proportion to its resistance, or, in other words, the one that will indicate the lowest e.m.f. applied to its terminals. Out of half a dozen types of sensitive galvanometers I found the best for my purpose an astatic instrument with one coil and a resistance of about half an ohm. To magnetise the needles as strongly as possible I made a coil of a very large number of turns of fine wire, and, putting the needles into it, flashed as great a current through it as the wire would carry; the astatic pair was then suspended and the stronger needle

stroked with a small weak magnet till the condition of instability was approached as nearly as was desired. A silk suspension was used for some time, but it was afterwards replaced by a quartz fibre, the finest I could make, but not the finest I could wish for. I put it in in hopes of doing away with the fatigue of the silk, which was continually shifting the zero of the instrument, and was somewhat disappointed in finding that the charge of zero was still observed after a large deflection. The mirror was a very fine concave one, of about 8in. focal length. Glass scales were found far preferable to opaque ones, but with glass scales one has again a variety of choices. Clear lines on black opaque ground, black lines on clear ground, and clear lines on red transparent ground (got by etching through the red "flashing" on common red glass) were all tried, and each has some advantages over the others, the red being delightful to work with in very strong light. I decided to use a dark scale on clear ground, and ruled a half millimetre scale accordingly. I fixed it between the galvanometer and a frosted window of northern aspect, to make sure of its always being well lighted. Its distance from the mirror was about 4ft. The image formed about 9in. from the mirror was capable of being magnified about ten diameters without sacrifice of distinctness, and a Ramsden eyepiece provided with cross wires was used to examine it; tenths of a scale division could be estimated, equivalent to measuring to $5''$ of arc in the movement of the magnet. A deflection of one scale division would be produced by an e.m.f. of 4 or 5 absolute units, according to the resistance of the junction being measured. A Thomson galvanometer of 10,000 ohms, to be of equal sensitiveness, would have to indicate 10^{-12} ampere.

The method of observation used is diagrammatically shown in the figure. E is a battery, R a high resistance, r a low resistance (generally 1 ohm), G the galvanometer, e the junction whose e.m.f. is to be measured. R is adjusted till no current flows through the galvanometer.



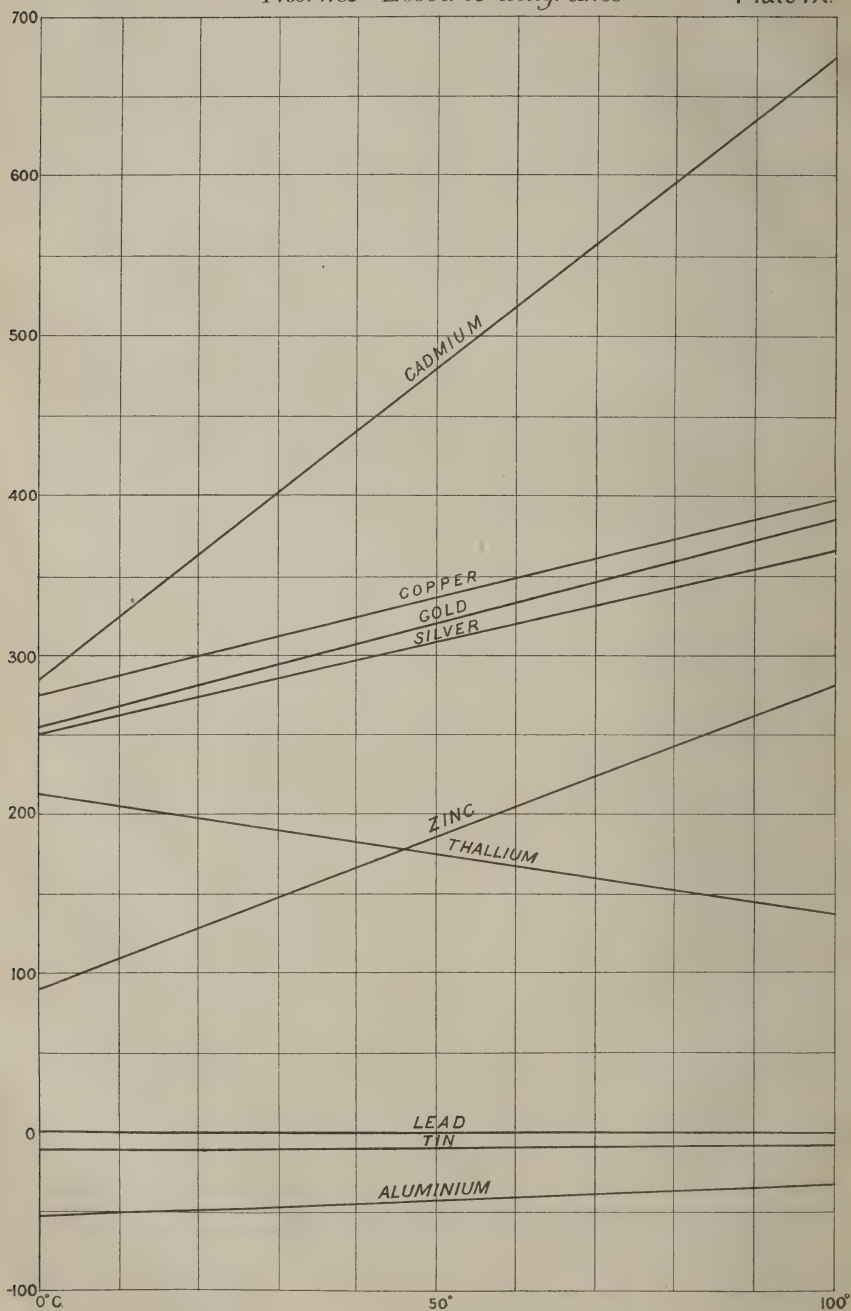
Then if C be the current through the large circuit e is equal to the e.m.f. at the ends of r , i.e., $e = Cr$. The current might be determined either by using a constant cell and using known resistances, or by measuring it directly by a tangent galvanometer or current balance. The former method was used. For a constant cell the

choice was open for one or other of the various forms of Standard Daniell or the Latimer Clark cell. I first tried Fleming's Daniel

cell, but found that the liquids diffused into one another too quickly, and that it would require attention every few minutes, and so turned my attention to Clark cells. Professor Threlfall and Mr. Pollock had pointed out (*Phil. Mag.* 1891), its suitability for small constant currents as well as for constant e.m.f. on open circuit. I set up three, following Lord Rayleigh's directions as closely as possible, and found that they gave perfectly consistent results when closed through resistances of not less than 6,000 ohms, the minimum being still lower in the case of one of them.

To eliminate thermo-electric effects other than the one being measured, I took a copper wire of the same resistance as the two metals whose junction was being examined, and arranged it as an alternative circuit, so that by closing the galvanometer-key the deflection produced was that due to the unequally heated portions of the circuit. Though this consisted only of brass and copper, I do not remember ever closing circuit without getting a deflection, so sensitive was the galvanometer. Both junctions of the metals being examined when copper was one of them, as it generally was, were immersed in an oil bath; and when the junction consisted of two other metals, say lead and tin, the junction of copper and lead and copper and tin were kept in the same cold bath, with a thermometer, the lead-tin junction being in the other, which was heated. No precautions were taken to keep the cold bath at a constant temperature, it being sufficient to know its temperature; it being possible, from the observations taken, to correct exactly for the rise or fall of the temperature of the cold junction.

The results obtained are, in a sense, unsatisfactory. Thus, while the mean error of a set of observations might be 5° C., the results would differ from another set, taken under exactly the same circumstances, by 3° or 4° . I am convinced that the so-called thermo-electric "constants" are not constant, but vary considerably with the least change in temper or condition of the body, and sometimes appear to vary arbitrarily. In a paper read before the Royal Society of Victoria, in the early part of this year, I discussed several months' experiments on the heating of a single metal, and showed that the ordinary thermo-electric phenomena are swamped at a temperature of about a red heat by great and arbitrary (apparently) e.m.f. *s.* generated in single metals themselves. In the case of half a dozen different metals one-third of a volt was reached by heating them to about $1,000^{\circ}$ C. In some metals this effect on a small scale could be observed at comparatively low temperature, and would interfere with the ordinary thermo-electric effect. To avoid it as far as possible I only went up to 100° C. in my observations, but even then I sometimes recognised, on a small scale, the irregularities with which I was familiar from previous work. In any set of observations, the relation between the e.m.f. e and the excess of the hot junction over the cold (assumed constant, or corrected for change) t , is

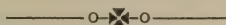


parabolic, $e = at + bt^2$, where b is positive or negative, according as the lines for the metals cut below or above the temperature of the cold junction, and is equal to half the difference of the Thomson effects for the two metals. To determine a and b as accurately as possible I worked it out for each series of observations by the method of least squares. Thus a and b must be determined so that $\Sigma (e - at - bt^2)^2$ is a minimum, the conditions being that $\frac{d\Sigma}{da} = 0$ and $\frac{d\Sigma}{db} = 0$, i.e.:—

$$\begin{aligned}\Sigma et - a \Sigma t^2 - b \Sigma t^3 &= 0 \\ \Sigma et^2 - a \Sigma t^3 - b \Sigma t^4 &= 0\end{aligned}$$

two equations which give a and b , but necessitate finding Σet , Σet^2 , Σt^2 , Σt^3 , Σt^4 . The finding of a and b from a dozen observations takes about 90 minutes arithmetic. I took three or more sets of observations on each junction examined, the mean results being embodied in the following table and shown graphically in the diagram (see Plate IX.):—

Aluminium	— 52.7 + .21 <i>t</i>
Tin	— 11.1 + .04 <i>t</i>
Zinc	91 + 1.92 <i>t</i>
Thallium	214 — .77 <i>t</i>
Silver	250 + 1.15 <i>t</i>
Gold	254 + 1.31 <i>t</i>
Copper	276 + 1.22 <i>t</i>
Cadmium	285 + 3.89 <i>t</i>
Antimony	3,558 + 14.5 <i>t</i>



14.—A PECULIAR THERMO-ELECTRIC EFFECT.

By W. HUEY STEELE, M.A.



Section B.

CHEMISTRY.

1.—THE SUGAR STRENGTH AND ACIDITY OF VICTORIAN MUSTS, WITH REFERENCE TO THE ALCOHOLIC STRENGTH OF VICTORIAN WINES.

By W. PERCY WILKINSON.

PART I.

The present is a second instalment of a systematic examination of Victorian and other Australian wines with a view to making a scientific comparison between these wines and the typical French and German, for which such elaborate data have been published by various French chemists (Fauré, *Analyse chimique et comparée des Vins de la Gironde*; Portes & Ruysen, *Traité de la Vigne et de ses produits*, 1886; Gayon, Blarez, & Dubourg, *Analyse chimique des Vins de la Gironde*, 1888; and numerous analyses by Houdart, Girard, and others, quoted in Viard's *Traité Général de la Vigne et des Vins*, 1892), and the German Imperial Commission for Wine Statistics, appointed in 1884 (*Zeitschrift für Anal. Chemie*, 27, *et seq.*).

In the first instalment (*Journal of the Board of Viticulture for Victoria*, May, 1892, pp. 81-96) it was pointed out, as the result of determinations on 600 Australian wines, that the average strength of Australian wines is 12 grammes of absolute alcohol per 100 cubic centimetres, as compared to an average of 8 grammes per 100 c.c., characteristic of French and German wines (nearly 2,000 samples).

In view of the great practical importance of the fact that Australian wines are half as strong again in alcohol as French and German, it was necessary to ascertain whether it is due to a corresponding excessive sugar strength in Australian musts. Some attention had already been given to the relation of Australian musts to wines, resulting in the publication from time to time of specific gravities of musts, by the Hunter River Vineyard Association from 1847 onwards, by the Royal Commission appointed to inquire into the Alcoholic Strength of South Australian Wines in 1874, and by H. Lumsdaine, Chief Inspector of Distilleries for New South Wales, 1875. These determinations demonstrated the high specific gravity, and accordingly the high sugar strength of Australian musts as compared to French and German. (The

South Australian Commission of 1874 found an average specific gravity of 1·118 from seventeen samples of grapes, representing 28·4 grammes of sugar per 100 c.c.). The reason for the difference in the alcoholic strength of the wines may therefore be partly ascribed to a difference in the sugar strength of the musts. As these previous determinations of the specific gravity of Australian musts were very few, it seemed desirable to make determinations for a number of typical Victorian samples, and at the same time to measure the acidity of the same musts, on account of its radical importance to the character of a wine.

During the Victorian vintage of 1893, 119 samples of must were examined, and as the determinations for each were made on the vineyard where it was produced, and as the vintage season is short and the vineyards are widely scattered, it was not possible for me, single-handed, to do more than determine the specific gravities and acidities of the 119. The separate determinations for each sample are given in the tables appended, also with notes indicating the district, name of vineyard, variety of grape, condition of grapes, date of examination. The specific gravities are referred to a temperature of 15° C. and water at 15° C., the acidity is given as free acids, calculated in the usual manner as tartaric acid, in grammes per 100 c.c. of must. The sugar strength given in the tables as grammes per 100 c.c., is derived from the specific gravity, according to a table in *Traité de la Vigne et de ses produits*, Portes & Ruyssen, vol. II., 1886. Salleron's allowance being made in that table for the effect of matters in the must other than sugar on the specific gravity. This allowance has been obtained as empirically suitable for French musts, and it remains to be ascertained how far it applies accurately to Australian musts, but for present purposes it must be accurate enough. In addition to sugar strengths and acidities the ratio of acidity to sugar strength is given in the last columns as parts of acid to 100 parts of sugar.

From these determinations on 119 musts an average can be obtained for comparison with the French and German average, as given in the following small table :—

	Specific Gravity, 15°/15° C.	Sugar, Grammes, per 100 c.c.	Free Acids, as Tartaric Acid, Grammes, per 100 c.c.	Parts of Acid to 100 parts Sugar.
France	1·083	19·1	·79	4·13
Germany	1·075	17·0	·96	5·65
Victoria	1·108	25·7	·72	2·80

The great sugar strength of Victorian musts is quite conspicuous in this table; it is nearly half as great again as those of the musts

of Germany and France. The acidity is also lower, and though not much lower absolutely it is much lower in relation to equal quantities of sugar. In determining the relation to these sugar strengths of musts to the alcoholic strength of the resulting wines, on the supposition that all the sugar is fermented, we can use Pasteur's result (*Annales de Chimie et de Physique*, 3rd ser. 58, p. 330), that the sugar gives half its weight of alcohol. Accordingly our average Victorian must of 1893 would, if completely fermented, give a wine containing 12.8 grammes of alcohol per 100 c.c., while the average alcoholic strength of Victorian wines previously given by me is nearly 12 grammes of alcohol per 100 c.c. Thus it appears that the high sugar strength of Australian musts explains the high alcoholic strength of Australian wines. When the same comparison is made for French and German musts and wines there is the same agreement; thus, the average German must, were all its sugar fermented, would give a wine containing 8.5 grammes of alcohol per 100 c.c., the actual average strength of German wines being 7.6 grammes per 100 c.c.; similarly with the French.

It is obvious that if Australian wines are to be brought nearer to the French and German standard the musts must be lowered in sugar content and raised in acidity. As to definite methods of achieving these desirable ends, special practical experiments in cultivation and in accurate timing of the vintage seem to be required. Apparently it is almost uniformly the practice in Victoria to allow the grapes to become over-ripe before gathering. It ought to be possible on each vineyard to determine a point in the ripening at which sugar and acid stand nearly in the proportion characteristic of French and German musts. By reducing the sugar strength the alcoholic strength of the resulting wine will be reduced, and by increasing the acid the material will be provided for the formation of those ethers which are regarded as giving the higher qualities to a wine. In connection with this it is interesting to know that as long ago as 1851 the great Liebig (*Letters on Chemistry*, 3rd ed.) says, "The free acids which are present in fermenting juice take a most decided part in the formation of those aromatic matters upon which odor and flavor depend. The wines of southern regions are produced from perfectly ripe grapes; they contain tartar, but no free organic acids; they scarcely possess the characteristic odor of wine, and with respect to bouquet or flavor they cannot bear a comparison with the nobler French or Rhenish wines."

Associated with the question of sugar strength, there is an interesting result of recent researches on the sugars, that the sugar in grapes is a mixture of dextrose and levulose, the latter preponderating in over-ripe grapes and the former in unripe (*Mach & Portele, Bied. Centr. Blatt.*, 1881; *Jour. Chem. Soc. Abstr.*, 1881, p. 1061), and as levulose is less fermentable than dextrose (*Dubrunfaut, l'ortès and Ruysen*, vol. II., p. 214; *Bornträger, Zeit. für ang. Chemie*,

1892; Jour. Chem. Soc. Abstr., 1893, p. 169) there is a tendency for some of the levulose of the must to remain unfermented, in which case it is liable to produce secondary fermentations.

To sum up: Victorian musts contain nearly 50 per cent. more sugar than they ought, if desired to give a wine of the average French and German alcoholic strength. A reduction in the sugar and an increase of the acidity of musts are the problems in Australian viticulture which demand the earliest attention. It will be seen in the detailed tables that some musts approach the French and German standard much more closely than others, so that the problem is one capable of practical solution.

It is with great pleasure that I desire to acknowledge the facilities rendered me in this work, in the middle of their own busiest time, by the proprietors of the vineyards at which the tabulated determinations were made.

VICTORIAN MUSTS, 1893.

Progressive Number.	Name of Vineyard.	Variety of Grape.	Condition of Grapes.	Date of Examination.	Specific Gravity 15°/15° C.	Sugar Grams per 100 c.c.	Free Acids, calculated as Tartaric Acid, Grams per 100 c.c.	Parts of Acid to 100 parts Sugar.
NORTHERN GOULBURN VALLEY.								
ECHUCA DISTRICT.								
1 ..	Tongala	Muscat	Over ripe, much shrivelled	Mar. 9	1.124	30.0	.34	1.13
2 ..	"	"	Entirely shrivelled berries and raisins	" 12	1.160	39.0	.70	1.80
3 ..	"	Burgundy	Uniformly over ripe	" 9	1.125	30.3	.76	2.50
4 ..	"	"	Perfect maturity	" 10	1.113	27.1	.75	2.77
5 ..	"	"	Over ripe, partly raisins	" 11	1.144	35.4	1.12	3.16
6 ..	"	"	Clear must from No. 5 (after standing two hours)	" 11	1.140	34.3	.76	2.22
7 ..	"	Pedro Ximenes	Thoroughly ripe	" 10	1.093	21.8	.82	3.76
8 ..	"	Verdelho	Perfect maturity	" 10	1.108	25.8	.86	3.33
9 ..	"	Terret	"	" 10	1.096	22.6	.76	3.36
10 ..	"	Riesling	Average from press	" 11	1.092	21.5	.82	3.81
11 ..	"	"	"	" 14	1.096	22.6	.76	3.36
12 ..	"	"	"	" 17	1.101	23.9	.75	3.14
13 ..	"	Cabernet Sauvignon	Perfect maturity	" 12	1.117	28.2	.75	2.66
14 ..	"	Hermitage	Slightly over ripe	" 12	1.124	30.0	.82	2.73
15 ..	"	Dongelinho di Castillio	Perfect maturity	" 12	1.116	27.9	.86	3.08
16 ..	"	Black St. Peter	"	" 12	1.088	20.4	.60	2.94
17 ..	"	Unknown	"	" 12	1.116	27.9	.75	2.68
18 ..	"	Malbec	"	" 13	1.112	26.8	.75	2.77
19 ..	"	Carnigane	"	" 13	1.094	22.0	.62	2.82
20 ..	"	Unknown	"	" 13	1.133	32.4	.80	2.47

21 ..	"	Chasselas	Slightly over ripe	13	1.107	25.5	.45	1.76
22 ..	"	Terret and Hermitage	Average from vat	"	1.114	27.4	.62	2.26
23 ..	"	Black Prince	Perfect maturity	"	1.096	22.6	.75	3.32
24 ..	"	Grenache	Slightly over ripe	"	1.120	29.0	.76	2.62
25 ..	"	Doradillo	Perfect maturity	"	1.094	22.0	.41	1.87
26 ..	"	Sultana	Uniformly over ripe	"	1.120	29.0	.62	2.14
27 ..	"	Sweetwater	Perfect maturity	"	1.100	23.6	.75	3.17
28 ..	"	Trebbiano	"	"	1.114	27.4	.65	2.37
29 ..	"	Mataro and Hermitage	Average from vat	"	1.117	28.2	.62	2.20
30 ..	"	Mataro	Thoroughly ripe	"	1.096	22.6	1.12	4.95
31 ..	"	Mataro	Perfect maturity	"	1.106	25.2	.62	2.46
32 ..	"	Hermitage	"	"	1.107	25.5	.76	3.00
33 ..	"	Hermitage	"	"	1.123	29.8	.76	2.55
34 ..	"	Riesling	Average from press	"	1.100	23.6	.65	2.80
35 ..	"	Hermitage	Uniformly over ripe	"	1.116	27.9	.65	2.30
36 ..	"	Morillon	Perfect maturity	"	1.080	18.3	.75	4.10
37 ..	"	Terret	"	"	1.116	27.9	.55	2.00
38 ..	"	Black Prince	Slightly over ripe	"	1.090	21.0	.62	3.00
39 ..	"	Mataro	Quite over ripe	"	1.130	31.6	.62	1.96
40 ..	"	Black St. Peter	Slightly over ripe	"	1.084	19.4	.76	3.91
41 ..	"	Terret	Over ripe, much shrivelled	"	1.100	23.6	.75	3.18
		Mean			1.110	26.3	.72	2.72
		Max.			1.160	39.0	1.12	4.95
		Min.			1.080	18.3	.34	1.13

SOUTHERN GOULBURN VALLEY.			
NAGAMBIE DISTRICT.			
1 ..	Château Tahbilk	White Hermitage	April 8
2 ..	"	Riesling	" 8
		Fairly mature	
		Perfectly ripe	
			.75
			.90
			26.0
			22.3
			1.109
			1.095
			2.90
			4.03

Victorian Musts, 1893—continued.

Progressive Number.	Name of Vineyard.	Variety of Grape.	Condition of Grapes.	Date of Examination.	Specific Gravity 15°/15° C.	Sugar Grams per 100 c.c.	Free Acids, calculated as Tartaric Acid, Grams per 100 c.c.	Parts of Acid to 100 parts Sugar.
SOUTHERN GOULBURN VALLEY— <i>continued.</i>								
NAGAMBIE DISTRICT— <i>continued.</i>								
3 ..	Château Tahbilk	Gouais	Perfectly ripe	April 8	1·091	21·2	·82	3·86
4 ..	"	Shiraz	"	" 8	1·100	23·6	·92	3·90
5 ..	"	Black Prince	"	" 8	1·081	18·6	·62	3·33
6 ..	"	Pedro Ximenes	"	" 8	1·074	16·7	·45	2·70
7 ..	Goulburn Valley	Doradillo	Fairly mature	" 8	1·065	14·3	·48	3·35
8 ..	"	Chasselas	Perfectly ripe	" 8	1·100	23·6	·52	2·20
9 ..	"	Verdeilho	Slightly over ripe	" 8	1·116	27·9	·85	3·05
10 ..	"	Hermitage	Average from press	" 8	1·116	27·9	·82	2·93
11 ..	"	Mataro	Perfectly ripe	" 8	1·103	24·4	·85	3·48
12 ..	"	Black Hambro'	Over ripe, much shrivelled	" 8	1·130	31·6	·92	2·90
13 ..	"	Muscat	"	" 8	1·150	37·0	·95	2·57
14 ..	Cameron's	Burgundy	Perfectly ripe	" 9	1·107	25·5	·92	3·60
15 ..		White Muscat	Slightly over ripe	" 9	1·095	22·3	·75	3·36
16 ..		Brown Muscat	Over ripe, much shrivelled	" 9	1·088	20·4	·85	4·16
17 ..		Mataro	Perfectly ripe	" 9	1·099	23·4	·65	2·77
18 ..	"	Hermitage	Over ripe	" 9	1·122	29·5	·75	2·54
19 ..	"	Black Hambro'	Perfectly ripe	" 9	1·101	23·9	·88	3·68
20 ..	"	Black Prince	"	" 9	1·092	21·5	·68	3·16
21 ..	"	Riesling	"	" 9	1·101	23·9	·75	3·14
22 ..	"	Chasselas	"	" 9	1·092	21·5	·55	2·66
23 ..	"	Pedro Ximenes	"	" 9	1·091	21·2	·55	2·60
24 ..	"	Baxter's Sherry	"	" 9	1·094	22·0	·82	3·73

Mean	1.100	23.6	.75	3.18
Max.	1.150	37.0	.95	4.16
Min.	1.074	16.7	.45	2.20

1 ..	Hadley Bros.	Riesling	Mar. 30	1.092	21.5	.84	3.92
2 ..	"	Shiraz	" 30	1.102	24.2	.71	2.93
3 ..	Staghorn	Burgundy	" 30	1.132	32.2	.80	2.48
4 ..	"	Muscad	" 30	1.136	33.2	.61	1.83
5 ..	"	Verdelho	" 30	1.125	30.3	.71	2.34
6 ..	"	Tokay	" 30	1.109	26.0	.60	2.31
7 ..	"	Riesling	" 30	1.096	22.6	.70	3.10
8 ..	"	Shiraz	" 30	1.114	27.4	.71	2.60
9 ..	Melville	Burgundy	" 30	1.136	33.2	.70	2.17
10 ..	"	Madera	" 30	1.087	20.2	.51	2.52
11 ..	"	Riesling	" 30	1.101	23.9	.65	2.71
12 ..	"	Verdelho	" 30	1.126	30.6	.70	2.28
13 ..	"	Shiraz	" 30	1.114	27.4	.65	2.37
14 ..	"	Aucarot	" 30	1.121	29.2	.71	2.43
15 ..	"	Muscad	" 30	1.130	31.6	.71	2.25
16 ..	"	Riesling	" 30	1.105	25.0	.60	2.40
17 ..	Westmoreland	Muscad	" 30	1.123	29.8	.60	2.01
18 ..	"	Burgundy	" 30	1.124	30.0	.65	2.17
19 ..	"	Verdelho	" 30	1.126	30.6	.65	2.12
20 ..	"	Shiraz	" 30	1.107	25.5	.60	2.34

Mean	1.115	27.6	.67	2.42
Max.	1.136	33.2	.84	3.92
Min.	1.087	20.2	.51	1.83

YACKANDAH DISTRICT.

Victorian Musts, 1893—continued.

Progressive Number.	Name of Vineyard.	Variety of Grape.	Condition of Grapes.	Date of Examination.	Specific Gravity 15°/15° C.	Sugar Grams per 100 c.c.	Free Acids, calculated as Tartaric Acid, Grams per 100 c.c.	Parts of Acid to 100 parts Sugar.
SOUTHERN GOULBURN VALLEY—continued.								
BARNAWARTHA DISTRICT.								
1 ..	Bordeaux	Malbec	Perfectly ripe	Mar. 27	1.104	24.7	.75	3.03
2 ..	"	Shiraz	"	" 27	1.109	26.0	.92	3.54
3 ..	Fairview	Muscat	Entirely over ripe	" 27	1.158	38.6	.72	1.86
4 ..	"	Malbec	Slightly over ripe	" 27	1.117	28.2	.58	2.05
5 ..	Mundadda	Riesling	Average from crusher	" 28	1.112	26.8	.50	1.86
6 ..	"	Gozais	"	" 28	1.100	23.6	.58	2.45
7 ..	"	White Hermitage	Perfectly ripe	" 28	1.112	26.8	.56	2.10
8 ..	"	Baxter's Sherry	"	" 28	1.086	19.9	.53	2.66
9 ..	"	Chasselas	"	" 28	1.104	24.7	.53	2.14
10 ..	"	Shiraz	"	" 28	1.123	29.8	.73	2.45
11 ..	"	Malbec	"	" 28	1.106	25.2	.67	2.65
12 ..	"	Mataro	"	" 28	1.103	24.4	.67	2.74
13 ..	Wakefield	Malbec	Slightly over ripe	" 28	1.112	26.8	.73	2.72
14 ..	"	Hermitage	"	" 28	1.126	30.6	.80	2.61
15 ..	Somerset	Malbec	"	" 28	1.116	27.9	.70	2.51
16 ..	"	Riesling	Perfectly ripe	" 28	1.101	23.9	.61	2.55
17 ..	"	Chasselas	"	" 28	1.092	21.5	.53	2.46
18 ..	Barnawartha	Sweet Water	Slightly over ripe	" 29	1.100	23.6	.45	1.90
19 ..	"	Gozais	Perfectly ripe	" 29	1.091	21.2	.61	2.88
20 ..	"	Chasselas	"	" 29	1.083	19.1	.41	2.14
21 ..	"	Malbec	Slightly over ripe	" 29	1.121	29.2	.70	2.40

22 ..	"	Muscat	Entirely over ripe	"	29	1.150	37.0	.83	2.24
23 ..	"	Isabella	Quite mature	"	29	1.102	24.2	.58	2.40
24 ..	"	White Hermitage	"	"	29	1.102	24.2	.70	2.90
25 ..	"	Ancarot	Slightly over ripe	"	29	1.130	31.6	.70	2.21
26 ..	"	Verdelho	Perfectly ripe	"	29	1.123	29.8	.75	2.51
27 ..	"	Shiraz	Over ripe	"	29	1.132	32.2	.77	2.40
28 ..	"	Riesling	Perfectly ripe	"	29	1.111	26.6	.70	2.63
29 ..	"	Grenache	"	"	29	1.100	23.6	.70	2.96
30 ..	"	Mataro	"	"	29	1.101	23.9	.66	2.76
		Mean				1.111	26.6	.65	2.46
		Max.				1.158	38.6	.92	3.54
		Min.				1.083	19.1	.41	1.86

BEECHWORTH.									
1 ..		O'Connor's	Shiraz (6 years old)	Perfectly ripe.	Mar. 30	1.101	23.9	.73	3.05
2 ..		"	Shiraz (26 years old)	"	" 30	1.100	23.6	.70	2.96
3 ..		"	Verdelho (6 years old)	"	" 30	1.108	25.8	.92	3.56
4 ..		"	Verdelho (26 years old)	"	" 30	1.107	25.5	.88	3.45
			Mean			1.104	24.7	.80	3.24

2.—WET TREATMENT FOR COPPER AND GOLD IN AUSTRALIA.

By GEORGE SUTHERLAND, M.A.

[SYNOPSIS.]

This paper calls attention to the special applicability of the method of extracting copper from its ores by the use of the protochloride of iron in the cases of Australian mines which are situated at great distances from the seaboard. Passing on to the consideration of the cupric salts it, cites their successful application to the purpose of the economical production of chlorine from hydrochloric acid, and suggests that chlorination for the extraction of gold might be rendered less costly than it now is if copper salts were utilised in this way. Finally, it discusses the reported successful combination of wet treatment and amalgamation for gold, by which it is claimed that, with the use of a current of electricity, gold may be extracted without coming into actual contact with the mercury.



3.—ON OSMOTIC PRESSURE.

By Professor ORME MASSON, M.A., D.Sc.

(WITHDRAWN.)



4.—THE EXPERIMENTAL INVESTIGATION OF OSMOTIC PRESSURE.

By Professor ORME MASSON, M.A., D.Sc., and J. B. KIRKLAND.

(WITHDRAWN.)



5.—ON HYPONITRITES.

By D. H. JACKSON, M.A., B.Sc.

[COMMUNICATED BY PROFESSOR ORME MASSON, M.A., D.Sc.]

Since the hyponitrites were discovered by Dr. Divers in 1871 (Proc. Roy. Soc. XIX., 425) a considerable number of investigations have been made on this subject, but in none of the papers published, with one exception (Menke, C.S.J., 33, 401), is there any account of the isolation of the alkaline hyponitrites.

The following work, therefore, was directed to the examination of sodium and ammonium hyponitrites and, incidentally, to the examination of the method of preparation of hyponitrite of silver, which is the starting-point in the preparation of other hyponitrites.

The yield of hyponitrite by the different methods of preparation varies from an amount which is described as bad and variable to a disputed maximum of 15 per cent. of the "theoretical quantity," and it was therefore considered advisable to ascertain, in the first place, if it were possible to readily improve this yield.

Pyrogenous Methods of Formation.—As nitrite is readily obtained from nitrate by heating, as well as by reduction in solution, it would seem, at first sight, that hyponitrite would most easily be obtained by heating nitrates, either alone or in contact with some reducing agent. Support is given to this view by Menke, who states that he obtained alkaline hyponitrites by heating sodium or potassium nitrate with iron filings in the presence or absence of sodium carbonate, and a considerable number of experiments were made, but without result, to test this method of preparation. It may be mentioned that Divers and Zorn have also been unsuccessful in repeating Menke's experiments. Moreover, there are several important reasons for thinking that Menke himself did not obtain hyponitrite, for (1) Menke states that his sodium salt gives a turquoise blue precipitate with copper sulphate, whereas Kolotoff has shown (C.S.J., Mar., 1893) that copper hyponitrite is yellow; (2) Menke boiled his product of reduction with water to extract the hyponitrite. As a matter of fact, sodium hyponitrite is very meltable under these conditions; (3) Menke heated his silver salt with ethyl iodide in a sealed tube and fractionated the product. Zorn has shown that this could not be carried out with real hyponitrite, as ethyl hyponitrite is violently explosive.

After trying unsuccessfully to obtain hyponitrite by reducing nitrate with aluminium, and also by reducing potassium and barium nitrates with barium amalgam, it was decided to adopt the original method of Divers, that is, reduction of nitrate with sodium amalgam, neutralisation of the resulting alkaline liquid with acetic acid, and precipitation of the silver hyponitrite with silver nitrate.

The Divers' Methods of Preparation.—Zorn states that the best amalgam for the purpose contains one part of sodium to thirty of mercury, but, as the product is still very small, a series of experiments was made with different strengths of amalgam, and these results showed that the largest yield was obtained with a very dilute amalgam and the smallest with a very strong one. Intermediate amalgams gave a secondary maximum. A similar series of experiments was conducted at 4°, and these show that the yield is much increased when the reduction is carried on at a low temperature.

Crude hyponitrite of silver, prepared according to Divers' method, invariably changes from a yellow to a green color. The percentage of silver in four cases in which the crude product was analysed varied from 77.4 to 84.8 (the theoretical percentage being 78.2 per cent.), and it was found on treatment of the hyponitrite with dilute sulphuric that this result was mainly due to the presence of more or less finely divided silver.

The only substances of a reducing character present in the liquid from which the silver hyponitrite is precipitated are potassium nitrite, acetic acid, and hydroxylamine acetate, and as KNO_2 will not reduce AgNO either in presence or absence of acetic acid, the reduction must be due to the hydroxylamine acetate. It thus appears that hydroxylamine acetate, though it does not reduce (faintly acid) silver nitrate, possesses the property of reducing AgNO to the metallic state. In accordance with this, it was found that the filtrate from the precipitated hyponitrite gave no trace of hydroxylamine, though the original alkaline liquid readily gave the tests for it. This conclusion as to the origin of the silver is to some extent confirmed by the recently published papers of Wislicenus (Ber. Apr., 1893, p. 773) and Paal (Ber., May, 1893, p. 1028). Wislicenus prepared hyponitrite by the action of hydroxylamine sulphate on sodium nitrite; Paal by the action of hydroxylamine hydrochloride on silver nitrite. Both found that the hyponitrite obtained contained metallic silver, so that other hydroxylamine salts, as well as the acetate, reduce AgNO . A specimen of AgNO was actually tried with acetic acid and hydroxylamine acetate, and, in accordance with what has been stated, was found to be reduced to metallic silver.

In order to prevent loss of hyponitrite, therefore, by this reduction it is advisable to treat the alkaline liquid with precipitated mercuric oxide. This decomposes the hydroxylamine. The crude hyponitrite obtained in this case does not contain metallic silver, and remains yellow in the dark under water.

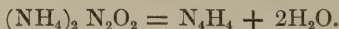
Preparation of the Sodium Salt.—Although sodium hyponitrite has never been satisfactorily obtained in the solid state, several facts are known about its solution in water. Thus Divers shows that this solution is alkaline to litmus, and that it gives precipitates with certain salts of the heavy metals. He also mentions that alkaline hyponitrites are decomposed by CO_2 . It was found that somewhat diluted solutions of sodium hyponitrite (prepared according to the equation $\text{AgNO} + \text{NaCl} = \text{NaNO} + \text{AgCl}$), or strong solutions which were slowly evaporated at the ordinary temperature (in vacuo) gave no appreciable quantity of solid hyponitrite. The residue contained, on the contrary, caustic soda, so that the sodium salt had evidently decomposed in accordance with the equation $2\text{NaNO} + \text{H}_2\text{O} = 2\text{NaHO} + \text{N}_2\text{O}$. As caustic soda is produced in this hydrolysis it was thought that a strongly alkaline solution of sodium hyponitrite would be more

stable. Such a solution was prepared by reducing a strong solution of Na NO_3 with sodium amalgam, and was evaporated in a vacuum over sulphuric acid. Although the evaporation took several weeks, the residue contained abundant hyponitrite of soda—a more soluble salt apparently than caustic soda. Some of the crystals were pressed between sheets of blotting-paper, redissolved in water, neutralised, and used to precipitate solutions of the heavy metals. Another portion of the crystals was treated with strong alcohol, and it was found that the hyponitrite remained undissolved, and could thus be completely separated from caustic soda. Dry sodium hyponitrite, freed from caustic soda in this way, was placed in an ordinary desiccator, and kept for weeks without being noticeably altered. The preparation of sodium hyponitrite by the above method is not a satisfactory one, however, as the evaporation of the alkaline liquid is very slow, and the product is impure. An attempt was therefore made to isolate the salt by precipitating a strong solution (from AgNO and NaCl) with alcohol. Crystals separated out immediately and settled on the sides of the flask in groups of plates. I satisfied myself that these were crystals of sodium hyponitrite, and converted them, after carefully drying in vacuo over sulphuric acid, into sodium sulphate in order to determine the percentage of sodium. Found 43.0 per cent. of Na. Calculated for the formula Na NO , 43.4 per cent. The salt, when separated by means of alcohol and dried in this way, has therefore the composition Na NO .

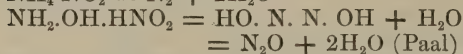
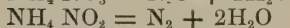
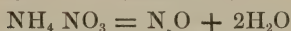
Before leaving the subject of sodium hyponitrite it may be well to lay stress upon its decomposition by water. This decomposition takes place in time at the ordinary temperature, and is much more rapid at higher temperatures. It gives an easy explanation of the small yield obtained by most of the known methods of preparation, and is in accord with the statement of Divers, that the decomposition of the oxyamido-sulphonates is by far the most productive method of preparation, since in this method the strongest potash obtainable is used to effect the decomposition of the oxyamido-sulphonate into hyponitrite and sulphite. It indicates, moreover, that success in obtaining large quantities of hyponitrite will depend on the use of some liquid which, like alcohol, will remove the hyponitrite out of the sphere of action of water. Hyponitrous acid and all the alkaline and alkaline-earth hyponitrites show more or less tendency to decomposition in presence of water.

Ammonium Hyponitrite.—Our knowledge of this is almost confined to the original statement of Divers, that it exists in solution, but is unstable. Ammonium chloride and silver hyponitrite, or barium hyponitrite and ammonium sulphate, readily react, and a solution containing hyponitrite is thus obtained, but it leaves no residue on evaporation under the pump, the smell of ammonia observed indicating the decomposition of the salt with separation

of ammonia. It was thought that the ammonium salt might be separated as the sodium salt had been, by the addition of alcohol to its aqueous solution. It was found, however, that no precipitate was thus obtained, the salt being soluble in alcohol; and an attempt was next made to obtain it by evaporating an alcoholic solution. Accordingly, anhydrous $(\text{NH}_4)_2\text{S}$ was prepared, and this was made to act on dry AgNO_3 . The silver sulphide was filtered off and the filtrate was evaporated under the pump over sulphuric acid, a column of KHO being placed between the pump and the desiccator to prevent the entrance of moisture to the alcoholic ammonium sulphide. In this way stellate groups of long needles were obtained; these contained ammonia, and at once gave the characteristic yellow AgNO_3 on direct treatment with AgNO_3 solution. They were evidently crystals of ammonium hyponitrite. Several small preparations of the ammonium salt have thus been made, but the salt has not been yet prepared in sufficiently large quantities to allow of a full examination of its properties. The decomposition of the salt by water, however, is a notable fact. It may be mentioned, in conclusion, that the decomposition of ammonium hyponitrite by heat is of considerable interest, for, as suggested to me by Professor Masson, it may be expected to decompose thus:—



This N_4H_4 may be the hitherto undiscovered tetrazone, or possibly its isomer ammonium hydrazoate. The following are analogous cases to that stated above:—



$\text{N}_2\text{H}_4 + \text{HNO}_2 = \text{HN}_3 + 2\text{H}_2\text{O}$ (Curtius, Ber., 1893, p. 1263). Similarly $\text{NH}_2.\text{OH}.\text{HNO}_2$, which I find to be readily obtained from $\text{NH}_2.\text{OH}.\text{HCl}$ and AgNO_3 , may be expected to decompose thus:— $\text{NH}_2.\text{OH}.\text{HNO}_2 = \text{N}_2 + 2\text{H}_2\text{O}$.

This investigation was carried out under the direction of Professor Masson, in the chemical laboratory of the University of Melbourne.



6.—THE PREPARATION OF HYPONITRITES FROM ETHYL NITRITE IN ALCOHOLIC SOLUTIONS.

By D. AVERY, B.Sc., F.C.S., Fellow and Tutor of Queen's College, University of Melbourne.

This investigation was undertaken at the suggestion of Professor Masson. The work of Mr. D. H. Jackson, who investigated

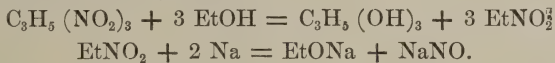
the preparation of hyponitrites in this laboratory, pointed to the partial decomposition, by the excess of water present, of the hyponitrite formed by the reduction of nitre; hence it was thought that in the absence of water a larger yield of hyponitrite might be obtained.

The preparation was based on the expectation that the reaction of sodium amalgam with ethyl nitrite would yield sodium hyponitrite and sodium ethylate.

The ethyl nitrite was obtained, as the most convenient method of formation, by the action of glyceryl trinitrate on absolute alcohol, glycerol being formed at the same time; but this apparently does not affect the reaction, and, being soluble in alcohol, is easily separated from the hyponitrite afterwards produced. The glyceryl trinitrate was prepared by the action of nitrogen trioxide on glycerol (Masson, J.C.S., 1883). The preparation is most conveniently performed in Varentrapp and Will bulbs—the absorption of the gas being very rapid and complete—the bulbs being kept cooled to about 10° in a current of water.

The trinitrate was separated as completely as possible from the water produced in a separating funnel, but not further purified.

About 18c.c. (23grms.) of the ether were thus prepared and introduced drop by drop into a large flask containing 2,000 grams of .9 per cent. sodium amalgam and a large excess (1 litre) of absolute alcohol. The ether sinks to the surface of the amalgam, reacting with the alcohol, forming ethyl nitrite and glycerol, and the ethyl nitrite then reacts with the sodium, forming sodium ethylate and sodium hyponitrite.



Heat is evolved during the reaction and the flask was kept cooled in a current of cold water. After the whole of the ether was introduced the flask was allowed to stand over night in the water. A voluminous white precipitate is formed and a considerable amount of ammonia evolved, hydroxylamine being, probably, also formed by the further reduction of the nitrite. The precipitate was separated from the mercury, filtered out, and washed with absolute alcohol, in which sodium hyponitrite is quite insoluble, till only slightly alkaline. This removes all the glycerol and sodium ethylate, as well as all reducing substances, such as hydroxylamine, which may be formed, and leaves the sodium hyponitrite only mechanically mixed with a little mercury. Experience showed that very thorough washing with alcohol is necessary to yield the hyponitrite in a pure state. It was then dissolved in water filtered from the mercury present, the filtrate being an almost pure solution of sodium hyponitrite. This was acidified with a drop of acetic acid and silver nitrite added, giving a bright yellow precipitate of silver hyponitrite, which did not blacken on exposure to light, as

samples obtained by the older methods invariably do unless at once purified by solution in dilute acid and reprecipitation with ammonia.

The silver hyponitrite was filtered off on a tared filter, washed free from silver nitrate, then treated with alcohol and ether to get rid of the water present, and finally dried in a vacuum desiccator over sulphuric acid and weighed, giving 3.0424 grams of silver hyponitrite, or about 6 per cent. of the theoretical yield. This is about the same as the yield obtained by Divers' original method.

To test its purity a weighed quantity of this hyponitrite was taken, dissolved in nitric acid, and titrated for silver, the amount found present being 2.2 per cent. below the theoretical amount calculated for pure silver hyponitrite.

In another experiment the materials were kept during the reduction process at 0° C. by immersing in a bath of melting ice instead of merely cooling to about 10° with a stream of water. In this case the reaction took very much longer, being still incomplete in forty-eight hours, and gave only a 2 per cent. yield of silver hyponitrite.

This method, though apparently not possessing any advantage over Divers' method in the yield of hyponitrite, is, however, not inferior to it in that respect, and possesses the advantage that the reducing substances formed in the reaction, being completely removed by washing with alcohol, the resulting hyponitrite is easily obtained in a pure state.



7.—ON THE INTERACTION OF NITRIC OXIDE AND SODIUM AMALGAM IN PRESENCE OF ALCOHOL.

By *GEO. W. MACDONALD, B.Sc., University of Melbourne.*

[COMMUNICATED BY PROFESSOR ORME MASSON, M.A., D.Sc.]

The results of this investigation, undertaken at the suggestion and with the guidance of Professor Orme Masson, being as yet incomplete, the author has deemed it advisable to give only a brief summary of the work so far accomplished, reserving a fuller account for a future date.

This investigation differs from previous work* in the use of sodium amalgam as the reducing agent and the substitution of absolute alcohol for water.

* Lossen. *Ann. Chem. Pharm.*, Suppl. Bd. vi., 220. Ludwig & Hein, *Ber., Deutsch. Chem., Ges.* 11., 671. Divers & Haga, *J.C.S.*, vol. 47, p. 361. Dunstan & Dymund, *J.C.S.*, vol. 51, p. 646. The first two researches deal with the production of hydroxylamine by reduction of nitric oxide in acid solution; the two latter with the formation of potassium hyponitrite by the action of an alkaline solution of potassium stannite on nitric oxide.

The method of experiment was as follows:—A stream of nitric oxide was passed through a bent tube, containing the sodium amalgam and alcohol, previously freed from all traces of air by a current of hydrogen passed through purifying and deoxidising agents. The product of the reaction, sodium hyponitrite, as it formed, separated out in the alcohol as a white finely-divided precipitate.

Although water was used in the first instance, this method of experiment was abandoned owing to the small yield of sodium hyponitrite (·54 per cent. of the theoretical yield) and the gradual decomposition of the soluble salt so formed in the presence of nascent hydrogen. By using absolute alcohol in place of water the yield was increased to 6 per cent. of the theoretical, and the decomposition above mentioned avoided. A small volume of nitric oxide (82·5c.c.) left in contact for forty-two hours with sodium amalgam and alcohol entirely disappeared, as such, with the production of about half its volume of nitrogen. All amalgams used contained less than 1 per cent. of sodium, and the duration of each experiment was some two hours; with stronger amalgams (3 per cent. to 4 per cent.), no yield of hyponitrite was obtained.

An experiment in which some 8 litres of nitric oxide were left in contact for nine days, under slightly increased pressure, with 1,470 grammes of amalgam and 150c.c. of alcohol, gave somewhat unlooked-for results. The sodium compound produced, which was found to contain no trace of mercury, while resembling sodium hyponitrite in respect to its being a white compound insoluble in alcohol and readily soluble in water, possessed other properties of a very peculiar nature in no respect resembling hyponitrite. While kept under alcohol it was somewhat flocculent in appearance, but immediately on exposure to air became of a pitch-like consistency, insoluble in ether and benzine even on boiling. When heated it swells up, and at a moderate temperature decomposes explosively. It is decomposed by both strong and dilute mineral acids, the former action being very energetic.

Reactions with solutions of mineral salts:—*Silver nitrate*—A white precipitate, soluble in excess of the sodium salt; readily soluble in either dilute nitric acid or ammonia, and reprecipitated on neutralisation as a chocolate-colored precipitate. The white precipitate when dry blackens immediately on exposure to light, and is explosive at a moderate heat. Copper sulphate produces a green precipitate, and ferric chloride a brown precipitate closely resembling the hydrate in appearance. Lead acetate gives a dirty-white precipitate, while with mercuric chloride no reaction takes place.

The absorption of nitric oxide, judging from a curve constructed, was very regular, and the gaseous products of the change were found to be ammonia and nitrogen, the latter by rough measurements being about half the volume of nitric oxide absorbed.

It appears from the foregoing that hyponitrite is produced during the first few hours, but that prolonged contact brings about a decomposition of the hyponitrite with production of a new compound possessing the somewhat peculiar properties which have been detailed. The explosive nature of the sodium and silver salts suggests the possibility of the compound being a derivative of hydrazoic acid, a conclusion which does not appear improbable when we consider that the hyponitrite was standing for a lengthened period in contact with sodium. The chemical nature of this compound is the subject which is at present under review, and the uncertainty on this score is the reason for the somewhat abbreviated account here presented.



8.—ON THE ORIGIN OF MOSS GOLD.

By Professor LIVERSIDGE, M.A., F.R.S.

(SEE PROC. ROY. SOC., N.S.W., 1893.)



9.—ON THE CONDITION OF GOLD IN QUARTZ AND CALCITE VEINS.

By Professor LIVERSIDGE, M.A., F.R.S.

(SEE PROC. ROY. SOC., N.S.W., 1893.)



10.—ON THE ORIGIN OF GOLD NUGGETS.

By Professor LIVERSIDGE, M.A., F.R.S.

(SEE PROC. ROY. SOC., N.S.W., 1893.)



11.—ON THE CRYSTALLISATION OF GOLD IN HEXAGONAL FORMS.

By Professor LIVERSIDGE, M.A., F.R.S.

(SEE PROC. ROY. SOC., N.S.W., 1893.)

12.—GOLD MOIRÉ-MÉTALLIQUE.

By Professor LIVERSIDGE, M.A., F.R.S.

(SEE PROC. ROY. SOC., N.S.W., 1893.)



13.—A COMBINATION LABORATORY LAMP, RETORT, AND FILTER STAND.

By Professor LIVERSIDGE, M.A., F.R.S.

(SEE PROC. ROY. SOC., N.S.W., 1893.)



14.—RESULTS OF ANALYSIS OF SOME SOUTH AUSTRALIAN WATERS.

By G. GOYDER, Jun., F.C.S.

(SEE PROCEEDINGS OF SECTION I.)



15.—NOTE ON THE DETERMINATION OF NITRATES IN THE ADELAIDE WATER.

By E. H. RENNIE, M.A., D.Sc., and E. F. TURNER.

Some time ago Warrington (C.S.J., xxxv., 377) made some experiments which went to prove that in determining nitrates in potable waters by the nitric oxide method it was not necessary, as intimated by Frankland, to remove any chlorine which might be present, but that, on the contrary, in some cases at any rate, the presence of chlorine was distinctly beneficial. In examining samples of the Adelaide water supply, we have made some observations which seem to confirm Warrington's results. The Adelaide water contains so much chlorine as to render it impossible to use the evaporation residue for the evolution of nitric oxide unless the chlorine be first removed, because of the large quantities of hydrochloric acid evolved. In our experiments, therefore, we first *completely removed* the chlorine in the usual manner, filtered off the silver chloride, evaporated the filtrate to dryness, took up in a very small quantity of water, and again filtered to remove some silver reduced by the action of organic matter on the excess of silver sulphate. In several experiments made in this way no nitric oxide was evolved on shaking with mercury and sulphuric acid in the

ordinary manner. On introducing a very small quantity of sodium chloride, however, and again shaking, reaction commenced, and in most cases nitric oxide was evolved corresponding approximately in quantity with the amount of nitrates present as determined by other methods; though, in some cases, there was a decided deficiency in the quantity of gas evolved. It should be stated that nitrates were present in small quantity, nitrogen as nitrates being only about .05 parts per 100.000. If considerably larger quantities were introduced, reaction set in without addition of sodium chloride, but no exact experiments were made to ascertain if there was any considerable deficiency. We are at a loss to account for these results, unless by supposing that the organic matter present in the water exerts a retarding or preventive influence on the reaction when the quantity of nitrates is small.



16.—PRELIMINARY NOTE ON THE COLORING MATTER OF *LOMATIA ILICIFOLIA*.

By E. H. RENNIE, M.A., D.Sc.

Surrounding the ripe seeds of *Lomatia ilicifolia* is a yellow powder. This substance is soluble in alcohol and the ordinary organic solvents, and also in hot water, from which it crystallises on cooling in fine needles. It can easily be purified by two or three crystallisations from hot water containing a little acetic acid, and it then consists of a mass of fine needles having a melting point of 126°-127° C. It dissolves in alkalis yielding a red solution. The combustion results and a molecular weight determination point to the formula $C_{16}H_{16}O_4$, but further experiments are necessary to definitely fix the formula. It yields apparently a diacetyl derivative, and salts, in which one atom of hydrogen is replaced by metal, the barium salt forming red needles. The examination of this substance is being continued.



17.—NOTES FROM THE LABORATORY OF THE WAL- LAROO SMELTING WORKS, SOUTH AUSTRALIA.

By T. C. CLOUD, Assoc. Royal School of Mines, F.I.C., F.C.S., and
G. J. ROGERS, Assoc. Royal College of Science.

(1.) DETERMINATION OF COPPER.

The determination of copper by electrolysis was first proposed by Gibbs in 1864. The separation was made from a sulphuric acid

solution; this method is very exact when the solution consists of pure or nearly pure sulphate of copper, but it is not satisfactory when iron is present. With large quantities of iron present, as frequently occurs in the case of an ore analysis, the separation of the copper is unduly prolonged, sometimes more than twenty-four hours being required for complete precipitation. In 1869 Luckow showed that a nitric acid solution could be used and was much more advantageous than the solution of the sulphate. With slight modifications this process has been the one in general use at the Wallaroo Smelting Works for the past twenty years, and has given great satisfaction, and we propose to place before you the methods and apparatus used for the purpose.

Apparatus.—The battery used consists of four cells of the Meidinger type, joined in series. Two such batteries are kept going for ordinary work. The negative element in this battery is a ring of rolled zinc $\frac{1}{4}$ in. thick, 4 in. high, and $4\frac{1}{4}$ in. outside diameter. To the top edge of this ring three pieces of stout sheet copper are soldered so as to project about $\frac{3}{4}$ in., and one of these carries the binding screw. These three projecting lugs serve to suspend the zinc ring in the upper part of the glass jar. The positive element is formed of a cylinder of 4 lbs. or 5 lbs. sheet lead, 11 in. high and 2 in. diameter. It may be formed of a piece of lead pipe, but is preferably made from sheet of the weight named, the joint being soldered up. The lower end of the cylinder is slit up for a distance of about 2 in. at four opposite points, and the tongues thus formed are spread out so as to nearly fit the inside diameter of the containing glass jar, which is $8\frac{1}{2}$ in. high and $4\frac{1}{4}$ in. diameter inside. To the top of the cylinder on the outside a copper wire is soldered to allow of connecting up the cells. The zinc and lead cylinders being placed in position, the cell is charged by filling up the lead cylinder with crystals of copper sulphate, and by then filling up the jar to within $\frac{1}{4}$ in. of the top with saturated solution of magnesium sulphate. When such a battery is first made up it requires to be put on closed circuit for about twenty-four hours before it comes into working order. It will then be noticed that some of the sulphate of copper has dissolved, and, passing through the openings in the lower part of the lead cylinder formed by the spreading abroad of the tongues mentioned above, has formed a well-defined layer of this substance at the bottom of the jar, while above it rests the magnesium sulphate solution. In turn one cell in each battery is cleaned up every week, *i.e.*, the copper which has deposited on the lead is removed by gentle hammering; the copper sulphate crystals and the magnesium sulphate solution renewed. In this way the battery is kept very constant for any length of time. Four such cells yield a current of 1.15 ampères at 2 volts. If the battery is allowed to stand for more than twenty-four hours on open circuit the two liquids commence to diffuse; copper deposits on the zinc cylinder and the battery when required

does not work satisfactorily, so that if not required for work it is desirable to place it on closed circuit for about half an hour in each twenty-four. For receiving the deposit of copper we use a cathode formed of a platinum cylinder. The solution is plated out in a beaker. The platinum cylinder is $1\frac{5}{8}$ in. high, $1\frac{1}{2}$ in. diameter, about $\frac{1}{8}$ in. thick, and has riveted or soldered to it a platinum wire about $\frac{1}{16}$ in. diameter, $4\frac{3}{8}$ in. long, formed into a hook at the upper end. The weight of such cylinder is 44 grms. The anode is formed of a piece of platinum wire $\frac{1}{16}$ in. diameter, 19 in. long, of which about $10\frac{1}{2}$ in. is formed into a flat spiral with the balance of the wire forming an upright stem rising from the centre of the spiral; the upper end of the wire is formed into a hook. These hooks formed in the wire serve to suspend the cathode and anode from their respective supports, and are preferred to binding screw attachments. The support for the cathode is so formed that the weight of the cylinder tends to make good electrical contact. The anode being comparatively light good contact is made by means of a brass spring resting upon it and forming part of the supporting arm.

The beakers used measure $4\frac{3}{4}$ in. high by $2\frac{1}{2}$ in. diameter, and hold about 9 oz. The process is conducted as follows:—1 grm. of ore is taken, 10 drops of strong sulphuric acid added, and a drop of hydrochloric acid to precipitate any trace of silver, 10 c.c. of strong nitric acid added, watch glass put on, and the whole mixed by gently twirling the beaker. It is then allowed to stand till temperature has gone down, and then heated upon the steam bath until all brown fumes have ceased to come off and all sulphur is dissolved. If the heating is slow and the mixture not actually boiled all the sulphur from an ore containing 25 per cent. sulphur will be readily oxidised. The cover and sides of the beaker are then washed down and the solution evaporated to dryness on the steam bath, the cake broken up with glass rod and heated on sand bath till fumes of sulphuric acid come off. It is allowed to cool, and 100 c.c. of nitric acid added (1 pt. conc. acid to 120 pts. water). It is not necessary to filter from insoluble residue, but electrodes may at once be placed in the solution and connected to the battery. The wire anode should be placed as near bottom of beaker as possible without actually touching it, and the lower edge of cylinder should be about $\frac{1}{8}$ in. off the spiral. The quantity of solution in the beaker should be such as to allow about $\frac{1}{4}$ in. of the cylinder to remain above it. The time allowed for electrolysis necessarily varies with the quantity of copper present, but twelve hours is generally allowed for amounts up to .5 grm. By means of a clock contact is made automatically at 9 p.m., or any other hour for which it may be set, so that the estimations are finished by 9 next morning. The electrolysis should not be allowed to continue for any long period after the copper is removed from the solution, as the texture of the deposit is apt to be injuriously affected thereby.

To ascertain if all the copper has been deposited the sides of the beaker are washed down with hot water, and the whole left one hour; if more copper then comes down on the previously clean portion of the cylinder a little more water is added, and so on until no more copper is deposited. The solution is drawn off with a syphon, and the solution gradually replaced with water whilst the current is still passing (beaker twice filled is generally sufficient); finally sufficient water is left in the beaker to cover the cylinder. The cylinder and spiral are now disconnected from battery, the cylinder removed from beaker and washed with hot water, then with alcohol, and dried by burning off the alcohol. The cylinder is hung in balance case for twenty minutes and weighed. The cylinders vary but little in weight; they lose slightly in use, and are in practice only weighed clean about once a week.

The following duplicate determinations made exactly as above show that the process admits of considerable accuracy:—

Ores	{ 14·190 }	{ 51·65 }	{ 19·045 }	{ 24·12 }	{ 17·405 }
	{ 14·155 }	{ 51·71 }	{ 19·045 }	{ 24·11 }	{ 17·345 }

Electrolytic copper taken, ·1127; found, ·1126.

The presence of bismuth to an extent of 1 per cent. calculated on the amount of copper in solution is indicated by a darkening of the deposited copper. With larger quantities of bismuth present the deposit is dark and spongy, and cannot be washed without loss. In such cases the method is modified as follows:—The solution of ore is made with aqua regia, and evaporated to dryness, taken up with hydrochloric acid, filtered and insoluble residue washed with hot water, filtrate precipitated with sulphuretted hydrogen, precipitated sulphides filtered, washed and oxidised with smallest possible quantity 1—1 nitric acid; solution nearly neutralised with ammonia, ammonium carbonate in slight excess added, and then a small quantity of ammonia warmed, and allowed to stand to cool; precipitate filtered off, washed, and filtrate made slightly acid with nitric acid, and evaporated to convenient bulk for plating out.

Arsenic and Antimony.—Of these the former is not precipitated until all the copper is removed, but antimony, according to Hampe, is deposited to a small extent together with the copper; in any case their removal is necessary if present to extent of more than 0·05 per cent. on the ore. We accomplish this by precipitating the copper in a caustic soda solution by means of sulphuretted hydrogen. The precipitate is filtered off from the solution containing arsenic and antimony dried, oxidised with nitric acid, evaporated just dry, taken up with water, and plated out.

Selenium and tellurium, if present, may be removed in a similar manner.

Silver, if in large quantity, is precipitated as chloride and filtered off, and the solution evaporated with sulphuric acid as before; if in but small quantity—less than 1oz. to the ton of ore—

the addition of a drop of dilute sodium chloride before plating out will prevent its deposition.

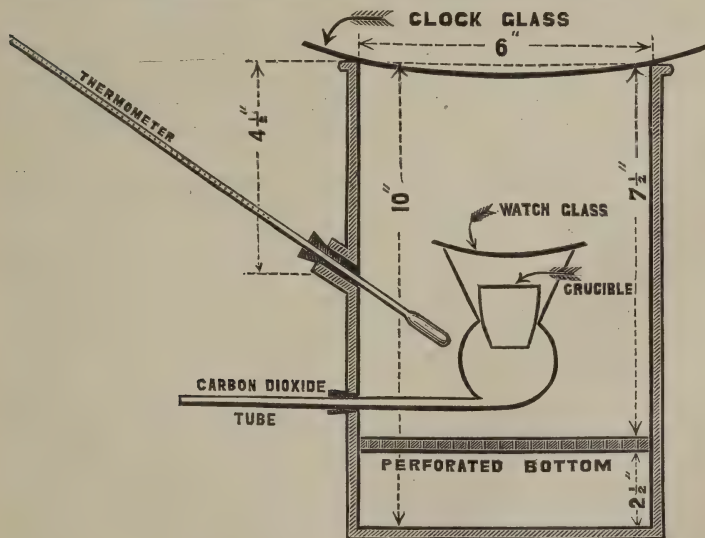
In the copper ores coming before us containing large quantities of silver, arsenic, or antimony, or both, are always present, and for the determination of the copper such ores are treated with aqua regia, evaporated to dryness, taken up with hydrochloric acid, filtered, and copper separated from arsenic and antimony, and plated out as above described.

(2.) DETERMINATION OF ANTIMONY IN ANTIMONIAL PYRITES.

We have recently had occasion to make a considerable number of antimony determinations in pyritic ores containing large quantities of both antimony and arsenic. The ordinary methods of separation and determination of the former constituent involve the expenditure of a considerable amount of time. By the method which we shall now describe it is possible to complete an estimation in an ordinary working day.

The process is a combination of the methods proposed by Clark, (J.S.C.I. 10. 444 and J.C.S. 46,424), and by Paul Fr. Zeits (31,537). Clark shows that on heating antimony and arsenic sulphides with hydrochloric acid and ferric chloride the arsenic distils over as chloride and the antimony is dissolved and remains in solution as trichloride. From this solution the antimony is precipitated as trisulphide with sulphuretted hydrogen in the ordinary manner. Clark then collects this precipitate on a weighed filter, washes free from sulphur with carbon bisulphide, dries at 130°, and weighs as trisulphide of antimony. We do not collect and weigh the sulphide in this manner, but, instead, make use of the very convenient process of Paul referred to above. The antimony sulphide is filtered off and washed on an asbestos filter in a Gooch crucible, gently dried, and finally heated in a stream of dry carbon dioxide. By this means all free sulphur is expelled and there remains pure trisulphide of antimony, which is allowed to cool and weighed. The process is carried on as follows:—Half a gram of the finely-ground ore is weighed out into 4½ in. porcelain dish, covered with funnel with bent stem; there is then added 5c.c. of a solution of ferric chloride (made by dissolving 20 grams of ferric chloride in 100c.c. of strong hydrochloric acid), together with 20c.c. of strong hydrochloric acid, and the dish and contents are heated on the water bath for half an hour; the funnel cover is then washed down with a little hot water and the solution evaporated to about 7c.c. to 10c.c. Care must be taken not to carry the evaporation too far, as, if all the hydrochloric acid is expelled, the trichloride of antimony will volatilise. Another 20c.c. of hydrochloric acid is now added and the evaporation carried to the same extent; then a third quantity of hydrochloric acid and the evaporation again

repeated. A few drops of tartaric acid solution are added and 20c.c. of hot water, the solution filtered into a 500c.c. beaker, the insoluble residue washed free from hydrochloric acid with hot water. In order to reduce most of the ferric chloride, and so prevent the precipitation of large quantities of sulphur by sulphuretted hydrogen, the solution is warmed with 2c.c. of saturated solution of ammonium bisulphite till smell of sulphur dioxide has disappeared and diluted to about 250c.c.; sulphuretted hydrogen is then passed through the heated solution till the precipitate becomes dense and granular and the excess of sulphuretted hydrogen driven off in the ordinary manner by a current of washed carbon dioxide. The precipitate is then filtered on a weighed Gooch filter, washed with hot water containing a little sulphuretted hydrogen and drained with the filter pump. The cap is placed on the bottom of the crucible, which is then transferred to the special air bath designed by Paul and figured in his paper. It consists of an iron bath, inside which the Gooch crucible is supported in the enlarged upturned end of a glass tube, through which the current of carbon dioxide is passed. This enlarged end of the glass tube is covered with a small watch glass and the whole bath closed by a clock glass. The apparatus we use is of the following dimensions:—



The current of carbon dioxide is then turned on and heat applied by means of a couple of large Bunsens or a Fletcher's burner; a slow current of carbon dioxide is kept going continuously, the temperature kept between 220° and 230° C. for half an hour. The

sulphur will be seen to condense at first on the inner watch glass, but slowly disappears. The whole is allowed to cool to about 100° in a current of carbon dioxide; the crucible is then transferred to the desiccator and weighed when cool. In the papers of Clark and Paul many experimental results are given showing the accuracy of their separate processes. To test the determination of the antimony by the above combined method the following experiments were made—Two samples of pyrites were analysed by the method of Fresenius (*Quant. Anal.*, p. 488), the arsenic being precipitated with magnesia mixture and the antimony weighed as oxide of antimony, and also by the above-described method.

	No. 1.	No. 2.
Results by method of Fresenius =	Antimony 19.34	Antimony 4.66
Results by above combined method =	Antimony 19.12	Antimony 4.60



18.—REMARKS ON THE FINENESS AND DISTRIBUTION OF GOLD IN NORTH GIPPSLAND.

By DONALD CLARK, B.C.E., *Director North Gippsland School of Mines.*

Perhaps there is no other district in the colony where the fineness of gold differs so much within small areas as North Gippsland. From the almost chemically pure soft yellow gold of the Nicholson River one has not to go many miles to find the greenish yellow alloy, electrum, in Swift's Creek.

The main geological features of the country have been so well mapped out by Mr. Howitt, F.G.S., the present Secretary for Mines, that special comment is almost unnecessary.

In many of his papers Mr. Howitt endeavored to trace the relationship of the strata to the fineness of the gold within certain areas; and though I think the occurrence of alluvial gold on any strata is accidental, yet valuable work could be done by determining how the fineness of the gold is influenced by associated rocks and minerals.

The fineness of gold, no doubt, depends originally on the solvents which held it in solution, and also on the amount of silver and baser metals present at the same time.

In auriferous belts in this district gold is distributed through the slates and sandstones, and sometimes in sufficient quantities to be remuneratively worked, but by far the largest proportion of gold obtained comes from the quartz reefs. In some cases, as at Yahoo Creek, the gold is on one side of the reef in slate, not a color being present in the quartz alongside; in other cases it is in small reefs which cross large barren ones, the latter being enriched where the contact plane is.

Almost every gold-bearing reef has arsenical pyrites in abundance, and in many instances this mineral is studded with free gold. As might be expected, minerals arising from arsenides, as pharmacosiderite, scorodite, and erythrite, are always present near a shoot of gold. Ordinary pyrites and marcasite, as well as pyrrhotite, also carry gold, whether found in the strata or in the reef. Pyrites in a vein of carbonate of lime at Long Gully gave a yield of over 1oz. per ton.

Zinc blende (sphalerite), or black jack, is always looked upon as a most favorable accompanying mineral, and in many instances specks of gold may be seen through it.

While all the oxidised and hydrated ores of iron derived from pyrites carry gold, in the Omeo district the gold occurs at the surface in a honey-combed iron-stained quartz, the gold being left in the cavities when the accompanying minerals were dissolved out. In that district a comparatively large amount of galena occurs in the reefs, and it probably has a lowering influence on the fineness of the gold. As rarer occurrences gold is found in wolfram in Swift's Creek, in bismuth at Wombat Creek, and probably in many other minerals not yet investigated.

As a general rule the fineness of alluvial gold is determined by that in the existing reefs, and the fineness is fairly constant for each creek; yet in one place I am familiar with, viz., the Sons of Freedom line of parallel reefs at Boggy Creek, the gold in the reef deteriorates as you go away from the porphyry, while the alluvial gold is constant in fineness.

The following table will show the decrease in fineness :—

Number.	Gold.	Silver.	Oxide Metals.	Locality and Remarks.
1	95·76	3·55	0·69	2 miles from porphyry
2	95·68	3·55	0·77	2½ " "
3	95·62	5·68	0·70	2½ " "
4	95·10	4·72	0·18	2½ " "
5	93·54	6·13	0·33	3 " "
6	93·45	5·65	0·90	3 " "
7	87·49	8·62	3·89	4 " "
8	84·42	14·16	1·42	4½ " "
9	76·35	18·20	5·45	4½ " "
10	74·95	21·97	3·08	5 " "
11	68·22	30·78	1·00	5 " "

The last sample represents the average of fifteen assays from the Monte Christo mine. That reef is interesting, because it contains cerargyrite and embolite in many intersecting clay seams. I found that when these were dissolved out with thiosulphate of soda, a small quantity of gold could always be obtained from the filtrate, as well as a considerable amount of lead.

The gold in this mine varied from a greenish-white alloy to one that did not contain more than 10 per cent. of silver. Beyond this boundary the gold increases in fineness, rising suddenly to 94 per cent.

It would thus appear that there is a well-defined belt of auriferous country having a low standard gold lying parallel to the intrusive igneous rock, and about four miles distant from its outcrop.

The alluvial gold table, on the other hand, shows a fineness from 94 to 97.

As a general rule I find the gold is better in quality when from slate, or a rubbly reef, than from solid quartz in the same neighborhood.

With regard to alluvial gold, it is my belief that it has all been derived in this district from pre-existing rocks. Pieces of clean, rounded gold, before the blowpipe, will give a fine white ash of silica; nuggets, with all their mammillary excrescences, are rarely without attached pieces of gangue, and when cut in half seem to be composed of strings and branches, pounded and battered into a rounded shape, while their mammillary form is due to erosion and not growth. The wearing down of a soft material like gold, when in a gravel wash, must be enormous, and but a small fraction can exist of that derived from ancient strata. In rivers and creeks where the gold has travelled—as the Mitchell, Tambo, and Lower Boggy Creek—the gold has the appearance of bran, so scaly and flaky is it.

Gold which is ragged with quartz attached may often be traced to some reef higher up the stream, thus showing its derivation.

From one creek, the Five-Mile, gold crystals may be obtained, principally having the forms of octohedrons or rhombic dodecahedrons.

With regard to the fineness, the following table will show that of the least variable creeks and rivers in the district, large variations occur in the Livingstone Creek and its branches within short distances, and as my information was incomplete about these I have discarded the results obtained.

With regard to the oxidisable matters, and substances other than gold or silver, silica is the main ingredient; in some samples, Merrijig, a trace of bismuth existed, and a small quantity of iron; copper was present in every sample, and lead occurred in that of Long Gully.

NOTES ON ALLUVIAL GOLD IN NORTH GIPPSLAND.

FINENESS OF GIPPSLAND GOLD.

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No.	Gold.	Silver.	Ox. Mat- ters.	Locality.	Remarks as to Geological Formation, &c.	Character of Gold.
1	98.87	1.02	0.11	Merrijig Creek, Wentworth River	On Silurian slates, near granite area	Coarse and nuggetty. Sample analysed was from a 14oz. nugget
2	98.49	1.16	0.35	Waterhole Creek, Nicholson River	Slate and sandstone, near granite area	Coarse and nuggetty
3	97.32	1.66	1.01	Store Creek, Nicholson River	" "	"
4	96.73	1.72	1.55	Boggy Creek, Mitchell River	From flats within two or three miles from porphyry	Coarse and also fine. Some specimens with quartz attached, others attached to oxides of iron
5	94.58	4.88	0.54	" "	From spurs within two or three miles from porphyry	"
6	97.54	2.46	—	" "	" "	Nuggetty and laminated (Howitt)
7	94.13	5.25	—	Boggy Creek	" "	"
8	97.17	2.17	0.66	Tabberabbera, two miles below Wentworth River	Middle Devonian overlaid by Upper Devonian	Scaly. A few quartz specimens (Howitt)
9	97.20	2.08	0.72	Dargo High Plains	Granitic country; gold out of ferruginous cement	Scaly, darkened with thin coat of manganese oxide
10	97.07	2.38	0.55	Mitchell River	Upper Devonian	Laminated and scaly (H.)

Notes on Alluvial Gold in North Gippsland—continued.

No.	Gold.	Silver.	Ox. Mat- ters.	Locality.	Remarks as to Geological Formation, &c.	Character of Gold.
11	96.70	2.10	1.20	Wentworth River, near Tinpot Creek	Adjoining granitic area	Sealy. In the adjoining creek (Tinpot Creek) large nuggets are found
12	96.34	3.66	—	Junction of Mitchell and Wentworth	Middle Devonian, with Upper Devonian outliers	Sealy (H.)
13	96.14	3.38	0.48	Tabberabbera, four miles above Wentworth	"	"
14	96.32	3.67	0.01	Tabberabbera, three miles above Wentworth	"	"
15	96.80	2.70	—	Good Luck Creek, Crooked River	Lower Silurian, adjoining granite	Nuggetty and laminated
16	95.54	3.63	0.83	Clifton Creek, Bainsdale	Lower Silurian, adjoining porphyry	Ragged and nuggetty
17	96.45	3.35	0.20	Sandy's Creek, Wentworth	Lower Silurian, adjoining granitic area	Waterworn. Elongated pieces and flattened grains
18	96.70	3.17	0.23	Nicholson River	"	Nuggetty and fine
19	96.66	2.52	0.81	Five-Mile Creek, Boggy Creek	Lower Silurian, adjoining quartz porphyries	Coarse and fine. Many specimens more or less crystallised
20	95.11	4.56	—	Shady Creek, Tambo River	Lower Silurian, adjoining granitic area	Nuggetty and laminated (H.)

21	94-84	3-88	1-18	Haunted Stream, Tambo River	"	"	Coarse and scaly
22	94-82	4-93	0-55	Lower Boggy Creek	Upper Devonian, on quartz porphyries		Scaly, and in small spherical shot-like grains
23	94-95	4-85	0-20	"	"	"	Scaly (H.)
24	93-97	5-62	—	Delegete River	Lower Silurian, near granite		Fine and scaly (H.)
25	94-01	5-29	—	Combyingbar Creek	"	"	Nuggetty and laminated (H.)
26	91-05	8-62	—	Tucker Creek, Wentworth	Lower Silurian	"	"
27	89-36	9-84	—	Policeman's Creek, Dargo	Hornblende granite		Fine, scaly, and in grains (H.)
28	86-93	12-57	—	Big River, Omeo	Metamorphic mica schist, pierced by greenstone, dykes, and felstone		Ragged and laminated (H.)
29	86-26	13-14	—	Dry Gully, Omeo	"	"	"
30	83-70	16-30	—	Granite Creek, Mitchell River	Adjoining granite		Laminated and ragged
31	82-10	15-42	3-58	Gladstone River	(?)		Laminated and waterworn. A few grains of osmium also present
32	84-96	14-13	—	Dargo Flat	Hornblende granite		Fine, scaly, and in grains (H.)
33	64-97	34-30	—	Swift's Creek, Omeo	Metamorphic mica schist		Ragged and laminated
34	97-30	2-27	0-43	Tinpot Creek	Adjoining granite		Ragged, with quartz attached
35	97-13	2-43	0-44	Swamp Creek	"		Lenticular and waterworn
36	95-50	4-41	0-09	Mitchell River, twelve miles above weir	Upper Devonian		Scaly

Section C.
GEOLOGY AND MINERALOGY.

1.—NOTES ON THE MACDONNELL RANGES.

By H. Y. L. BROWN, F.G.S.

2.—ON THE AGE OF CERTAIN PLANT-BEARING BEDS
IN VICTORIA.

By T. S. HALL, M.A., and G. B. PRITCHARD.

In Victoria we have a series of deposits containing plant remains which have up to the present been generally regarded as of Miocene age. It is our present intention to bring forward a few facts concerning these beds which, in our opinion, seem to point to the necessity of altering the age to which they should be referred.

LOCALITIES.

In the vicinity of Flemington, not far from the old Model Farm, a deposit of white plastic clay, containing plant impressions, occurs, lying on the denuded surface of the Upper Silurian rocks, and underlying the so-called Older Basalt.

Similar clays, said to belong to the same horizon, are recorded* as occurring on the west side of the Melbourne swamp, near Footscray.

In Mr. Wilson's quarry, at Berwick, we have fine, somewhat indurated clays, for the most part of a dark color, yielding numerous plant impressions, underlying the Older Basalt, and resting on the Upper Silurian rocks. Mr. R. A. F. Murray remarks† that "there is no doubt as to the lignites of McKirley's Creek and the Tarwin, in Gippsland, being of Miocene age, because they are overlaid by older volcanic rocks." In these cases also the bed-rock is Upper Silurian. Ferruginous, sandy, and clayey beds, containing fossil leaves, occur beneath the basalt of the Cobungra High Plains. Similar beds also underlie the basalt of the Dargo High Plains and the Bogong High Plains.‡ At Bacchus Marsh

* International Exhibition Essay, by R. Brough Smyth. 1873.

† Geo. and Phys. Geog., Vic., p. 165.

‡ Prog. Rep. Geo. Surv. Vic., No. v., p. 96, *et seq.*

ferruginous beds occur which contain numerous fossil leaves and fruits.*

At several localities in south-western and south-eastern Gippsland there are gravels, sandy beds, clays, lignites, and siliceous rock, ascribed to the same age as the beds above mentioned. They are generally found underlying the Older Basalt, though occasionally they occur capping some of the hills which are surrounded, though not covered, by the volcanic rock, and are found resting on Upper Silurian and on Mesozoic (Carbonaceous Series).

For further particulars of these beds, see Progress Report of the Geological Survey of Victoria, No. III., p. 146, *et seq.*; also No. v., p. 44-70.

The auriferous gravels of Hoddle's Creek, Upper Yarra, have yielded fossil fruits, and are overlain by the Older Basalt.

FOSSIL FLORA.

Cinnamomum polymorphoides (McCoy) occurs at Bacchus Marsh, the Cobungra, Bogong, and Dargo High Plains. (For description, see Prod. Pal. Vic., Dec. iv.)

Laurus Werribeensis (McCoy) occurs at Bacchus Marsh and Dargo High Plains. (See Prod. Pal. Vic., Dec. iv.)

Salisburia Murrayi (McCoy, MS.) occurs at the Dargo High Plains. (See Prog. Rep. Geol. Surv., No. v., p. 106.)

Lastrea Dargoensis (McCoy, MS.) occurs at the Bogong High Plains. (See Prog. Rep. Geol. Surv., Vic., No. v., p. 102.)

Tenopteris tenuissime-striata (McCoy, MS.) occurs at the Bogong High Plains. (See Prog. Rep. Geo. Surv., Vic., No. v., p. 102.)

Spondylostrobos Smythii (F. v. M.), *Phymatocaryon Mackayi* (F. v. M.), *Celyphina McCoyi* (F. v. M.), *Conchotheca turgida* (F. v. M.), *Platycoila Sullivanii* (F. v. M.), occur at the Tanjil, Gippsland.

The above fossils are described by Baron F. von Mueller in his papers on the New Vegetable Fossils of Victoria. They were first obtained from the Haddon gold drift, Ballarat, which is said to be of Pliocene age. We include them here because they are said to occur in deposits underlying the Older Basalt.†

Plesiocapparis prisca (F. v. M.) occurs at Hoddle's Creek, and is described along with the preceding.

Daphnogenea sp., from Bacchus Marsh.

Acer (?) sp., from Bacchus Marsh.

Ficus sp., from Dargo High Plains.

REMARKS ON THE FLORA.

Respecting the fossils of the Miocene beds of Bacchus Marsh, Professor McCoy has reported as follows:—"The fossil plants of

* Geology of District from Bacchus Marsh to Bass Straits, by R. Daintree, 1863; also, Geo. and Phys. Geog., Vic., Murray, p. 105.

† Geo. and Phys. Geog., Vic., Murray, p. 109.

the ironstones are strikingly distinguished from the Pliocene Tertiary leaf-beds of the Daylesford and other older gold drift deposits by the total absence of myrtaceous plants, which so strongly mark the recent forest foliage of Victoria. I have no doubt the fossil leaves from this locality indicate a Lower Miocene or Upper Eocene Tertiary flora, in which lauraceous plants form a remarkable feature. All the species seem new; but leaves of *Laurus*, *Cinnamomum*, *Daphnogenea*, and possibly *Acer*, are scarcely to be distinguished from species referred to those genera in the leaf-beds (of the geological age mentioned) of Rott, near Bonn and Enningen, especially the *Cinnamomum polymorphum* (Herr). Professor McCoy also remarks*—"The specimens from this locality (head of the Bundarra, i.e., Bogong High Plains) are of great interest from containing a new species of *Taniopteris*, *T. tenuissime-striata* (McCoy, MS.), the first example of this in Tertiary rocks in Australia, although well-known in rocks of this age in other parts of the world. There is also a *Lastrea*, *L. Dargoensis* (McCoy, MS.), allied to a Miocene species from the Arctic regions. With these are a few fragments of dicotyledonous leaves, apparently identical with some from Bacchus Marsh, but too imperfect for precise identification." The same authority, in the report above referred to, also remarks on specimens from the Dargo High Plains as follows:—"Several imperfect lauraceous leaves of undescribed species, occurring also in the Miocene Tertiary beds of Bacchus Marsh. With these is a most interesting specimen of a species of *Salisburia*, *S. Murrayi* (McCoy, MS.), nearly allied to some Miocene forms from the Arctic regions, but not hitherto found in Australian strata." Also, "The specimens are all clearly of Miocene Tertiary age, the *Cinnamomum polymorphoides* (McCoy) and *Laurus Werribeensis* (McCoy) being the only ones as yet described and figured, but several others are identical with forms in the Bacchus Marsh beds, bearing out my former suggestion of the geological identity of the deposits of these two localities. In addition to these are some imperfectly preserved impressions, apparently referable to the *Ficus Dionysia* (Massalongi) from the South European Miocene beds, and traces of at least two plants not previously observed."

AGE OF THE BEDS.

The apparent reason for determining these beds to belong to the Miocene age is a comparison of the fossil flora with that of Europe. Professor McCoy has stated that he has no doubt that the fossil leaves from Bacchus Marsh indicate a Lower Miocene or Upper Eocene Tertiary flora, but we are not aware of any subsequent reference to Upper Eocene age in any of the Victorian geological reports on these beds. As only a very few determined plants have

* Prog. Rep. Geo. Surv., Vic., No. v., p. 175.

as yet been recorded from the Victorian beds, any comparison with European Tertiary floras must have been of a somewhat slight nature. Then, with regard to the overlying basalt, the officers of the Geological Survey of Victoria determined the age of the so-called "Older Basalt" as Miocene, because they say they have observed it overlying marine Miocene beds, the latter said to have been determined upon their fossil contents. Mr. Murray remarks:—* "The older volcanic rocks are the latest products, and mark distinctly the close of the Middle Tertiary or Miocene era." In speaking of the basalt of the Dargo and Bogong High Plains, the same authority says:—† "The basalt or lava forming the high plains is here referred to the older volcanic (Miocene) period, immediately overlying, as it does, sedimentary deposits shown by their fossil flora to be of Miocene or Middle Tertiary age. Objection may be taken to this classification on the ground that the fact of basalt overlying Miocene deposits does not necessarily prove it to belong to that epoch; but the evidences here are to the effect that the Miocene beds were still in actual progress of deposition when the lava poured over them." At Curlewis, near Geelong, the Older Basalt is distinctly mapped and reported on by Daintree as overlying marine Miocene beds. Recently we had an opportunity of visiting this locality, and were surprised to find that the Older Basalt distinctly underlies the so-called Oligocene of the Survey. The fossils we obtained from these clays clearly indicate a lower horizon than Oligocene, most decidedly Eocene, and probably Lower Eocene, as the specimens were almost all identical with species occurring at the typical Eocene localities, such as Muddy Creek and Mornington‡; so that at this locality the "Older Basalt," with its upper surface showing considerable denudation, is clearly anterior to the deposition of the marine Eocene beds. This is also the case at Flinders, where an undoubted marine Eocene limestone rests on the denuded surface of the volcanic rock. On the Otway coast, at Eagle's Nest, a volcanic deposit is recorded, underlying Eocene beds (Miocene of Survey).§ Other localities showing the same sequence of the rocks have lately come under our notice.

Mr. Selwyn records|| a section on the Moorabool River, near Maude, where there is a band of older volcanic intercalated between marine Miocene beds, but we have not yet had an opportunity of visiting this locality, and so are not at present prepared to say anything further on it. Nowhere, so far as our observations have yet extended, have we observed the "Older Basalt" overlying or intercalated with the Eocene Series; so that from the evidence we have thus far adduced it can be clearly seen that the so-called

* Geo. and Phys. Geo., Vic., p. 109. † Prog. Rep. Geo. Surv. Vic., No. v., p. 108.

‡ Proc. Roy. Soc., Vic., N.S., vol. vi.

§ Geological Map of the Cape Otway District; also, Geelong Naturalist, vol. ii., No. 8, p. 3.

|| Intercol. Exhib. Essay., 1866-67.

"Older Basalt" of the localities mentioned is considerably older than it has hitherto been regarded, and, as there is a decided unconformity between it and the marine Eocene beds, which are now looked upon by some authorities as Lower Eocene, it is even probable that it may ultimately be found convenient to remove the basalt from the Tertiary Period.

Professor Tate and Mr. Dennant, in their paper on the Correlation of the Marine Tertiaries of Australia,* make the following remarks, which have an important bearing on this part of our paper:—"This basalt rests directly upon Mesozoic strata at San Remo, on the eastern shore of Western Port, while at Flinders, on the west, it is overlain by the Eocene Tertiary. The "Older Basalt" is commonly called Miocene, because the strata overlying it were assumed to belong to that period. Instead of such being the case they are, as we have endeavored to prove, of Eocene age, and the epoch of the basalt must be correspondingly altered. It cannot be younger than Eocene, and may ultimately prove to be Cretaceous."

Previous to the publication of the above paper we had come to similar conclusions from independent observations in the Bellarine Peninsula and elsewhere, and had communicated our results to the Royal Society of Victoria at their first meeting for this year.

Now let us look at the evidence we can obtain from a brief examination of the plant remains themselves. Taking the genera above mentioned, which are based on the leaf remains, we find that their distribution confines our attention between the limits of Cretaceous, as represented in the Laramie Group of America and Miocene as represented in Europe. Mr. Lester F. Ward, in his "Synopsis of the Flora of the Laramie Group," gives a table of the distribution of Cretaceous and Eocene plants,† which bears out the above statement.

From our remarks on the "Older Basalt," and its unconformable marine Lower Eocene cover, it can be readily seen that the limits are narrowed down to the consideration of Cretaceous on the one hand and very early Eocene on the other.

GENERAL REMARKS.

There are a few points with regard to certain deposits in some of the other colonies which tend to a great extent as confirmation of the above.

Professor Tate has already indicated his discovery of a Cretaceous fauna mixed with a Tertiary flora, which was at one time regarded as Miocene,‡ from a locality near Lake Frome, in South Australia.

* Trans. Roy. Soc. S.A., vol. xvii., pt. I., p. 212.

† U.S. Geol. Surv., 6th Report, 1885.

‡ Adelaide Philosophical Society, President's Address, 1879.

We have in this a somewhat parallel instance to the famous Laramie beds of North America. In the latter case a comparison with European floras was made, but was found very unreliable in face of the evidence obtained from stratigraphical position and palæontological evidence based on marine forms.

A peculiarity of lithological resemblance between some of the beds seems so marked a feature that it may be worthy of mention. In certain of the Victorian beds, particularly in the Gippsland district, a marked character is the presence of a siliceous cement, which has been suggested as probably due to hydrothermal action.* Certain Upper Cretaceous rocks of Queensland and South Australia are mentioned by some authors as being characterised by the occurrence of a similar cementing material.

The late Mr. C. S. Wilkinson has remarked on the apparent identity of certain plant-bearing beds of New South Wales with the Victorian beds in the following terms:—† “In many places on the Great Dividing Range and at various elevations up to 5,000ft. above the sea occur beds of conglomerate, siliceous sandstones, clays, and ironstones, containing impressions of leaves. In lithological character these beds have a perfect resemblance to the Lower Miocene leaf-beds of Bacchus Marsh in Victoria; some of the impressions of leaves in the former seem to be undistinguishable from the Victorian fossils.”

Baron von Ettingshausen, in dealing with similar material to that which occurs in the Victorian beds from Dalton, near Gunning, New South Wales, regards the fossil flora from that locality as Eocene, the classification being apparently based upon the plants themselves.‡ The same authority, in dealing with the fossils from Vegetable Creek, comes to the conclusion upon the same somewhat precarious method, that that fossil flora might be referred to Lower Eocene, from the European point of view.§ At the same time he draws attention to the close affinity of some of the forms to those usually belonging to the Cretaceous Period, but does not seem to lay very much stress upon them, as he says—|| “Examples indicating the attachment of our flora to that of the Cretaceous Period appear, however, to be only isolated when we take into consideration its numerous analogies to real Tertiary plants.”

We have shown that the age of the Victorian leaf-beds has been brought within comparatively narrow limits, and if Mr. Wilkinson's comparison holds good, and is still borne out when more is known of the various species occurring in the Victorian beds which have not yet received any attention, is it not possible that the New South Wales beds also may require to be placed further back in time?

* *Prog. Rep. Geol. Surv., Vic., No. III., page 148.*

† *Notes on the Geology of New*

South Wales, 1882, p. 56.

‡ *Contributions to the Tertiary Flora of Australia, pp. 8, 9.*

§ *Id., p. 77 et seq.* || *Id., p. 80.*

3.—ON THE OCCURRENCE OF FORAMINIFERA IN THE PERMO-CARBONIFEROUS ROCKS OF TASMANIA.

By *WALTER HOWCHIN, F.G.S.*

PLATES X. AND XI.

In 1889 Mr. Thos. Stephens, M.A., F.G.S., of Hobart, published a short note in the Proceedings of the Roy. Soc. of Tasmania (p. 54), on "Foraminifera in the Upper Palæozoic Rocks." The locality from which the foraminiferal rock was obtained was stated to be "the north-eastern district of Tasmania," and the testimony of Mr. R. Etheridge, jun., Government Geologist of New South Wales, was quoted to the effect that this was the first record of this division of the animal kingdom occurring in the Permo-Carboniferous rocks of Australia and Tasmania. In the same year Mr. Etheridge kindly forwarded to me samples of this interesting rock, together with two transparent slides which he had made by sectioning the stone. I have deferred until now any descriptions of these embedded forms, influenced by the hope that better material for their determination might be obtained; but, as this is not likely at present, it is perhaps better to publish a few notes on the subject which may draw the attention of geologists to the possible occurrence in other localities in Australia of foraminiferal rocks of this age.

Additional samples of the stone have been forwarded by Mr. Stephens, and, in answer to several queries, has kindly supplied the following particulars as to the stratigraphical position and locality of the rock in question:—"There is no particular name for the locality where I found the foraminiferal limestone some years ago; but it is on the right bank of the River Piper, not very far from a place called Lilydale. There are other outcrops of the same formation, or one very near it, in the neighborhood, but it was only in the one place that I was able to detect the foraminiferal remains. So far as I remember, they were only found associated with the characteristic fossils of the Permo-Carboniferous beds, which were present in great variety; but there was no sufficient exposure of any section to show the thickness of these fossiliferous bands. . . . The rock belongs to the marine beds near the base of our Permo-Carboniferous Series, and is associated with coal measures, containing a bed of free-burning shale, which appears to be on the same geological horizon as the Tasmanite of our Mersey district."

The rock in question is a dark-colored, compact limestone, exhibiting on its weathered faces gastropods, bivalves, fronds of polyzoa, &c., in bass-relief. When a fractured face of the stone is closely examined, it is seen to be largely composed of minute foraminiferal shells. Very few of these break clear of the matrix, so as to expose their exterior surface, but suffer fracture when the

stone is broken, and are therefore chiefly seen in section, the white lines of the chambers showing up very distinctly on the dark ground of the stone in which they are set.

The prevailing foraminifer (which occurs in this bed in astonishing numbers) undoubtedly belongs to the genus *Nubecularia*. This is evident, not only from its exhibiting the mode of growth characteristic of the genus, but is confirmed by the transparent sections, which show the test to be imperforate, whilst the objects give by transmitted light the dark-brown color that is eminently characteristic of the porcellaneous group to which *Nubecularia* belongs. The minuteness of the objects, coupled with the hardness of the matrix, renders it almost impossible to obtain examples of this form in a free condition, and it is not easy to mark off with clearness specific distinctions where the data are limited almost entirely to transparent sections. This is especially the case when dealing with a genus of so protean a habit of growth as the one under discussion; yet for reasons assigned below we have thought it advisable to give a varietal value to the features which distinguish these remote geological representatives of the genus from the closely-related modern *Nubecularia lucifuga*. It is with pleasure that I associate the name of Mr. Thomas Stephens, M.A., F.G.S., with this interesting foraminifer, for reasons that will be apparent.

NUBECULARIA LUCIFUGA, VAR. *STEPHENSII*, VAR. *NOV.*

Habit of growth closely resembling the type. Initial chamber, globular. Subsequent chambers, elongated and slightly inflated. Chambers arranged, either on a spiralline plan, in rectilinear order, or in irregular acervoline masses. Walls of the test, thin, uniform in thickness, and sharply defined in outline. Septal divisions marked on exterior surface by sunken lines.

A comparison of transparent sections of recent examples of *N. lucifuga*, and the form now under description, reveals a striking difference in the partitional walls. In the recent examples the walls are thick, irregular, and sometimes membranous, whilst the fossil form preserves a remarkably uniform thickness in its septal partitions. In existing examples the sutural lines are generally more or less obscured by an excessive deposit of shell substance on the exterior surface. The Tasmanian specimens, on the other hand, do not thicken the periphery by secondary deposits of shell substance, as is frequently the case with living forms. The present descriptions can only be taken as provisional. Should a portion of the rock in which they are contained be discovered sufficiently friable to yield the *Nubeculariæ* in a free condition, it may be found that they are practically identical with the recent species, or the differentiation may receive a higher value, requiring a specific rather than a varietal distinction from the existing species.

The geological range of the genus is extensive, although it has apparently found its maximum development in existing seas, and

in no part of the world does it appear more at home than on some of the Australian coasts. Messrs. Jones and Parker have figured two species of *Nubecularia* from the Upper Triassic clays of Chellaston, Derbyshire. It occurs sparingly in later Mesozoic and Tertiary formations of England and the Continent, and the author has obtained about half a dozen small examples of *N. lucifuga* from the Carboniferous limestone shales of Northumberland (M.S.), which is the lowest position in which it has been recorded in the geological series.

SPIROLOCULINA (?) *PLANULATA* (LAMK.).

The transparent rock sections exhibit a few *Spiroloculinae*, cut at various angles, and apparently all of the same species. One of these can be seen on Plate X., near the central line and one-fourth distance from the bottom, the line of section cutting the object transversely nearly through the centre of the test. The segments (about eleven in number) are narrow, of rounded contour, increasing slowly in size with the growth; the final chambers enlarge suddenly, and on one side there is an appearance of a carinate ridge running longitudinally along the exterior periphery. No other example of *Spiroloculina* in the sections exhibit the carinate feature, and it may be only a defect in grinding the object. It is impossible to determine the specific relationship of this form with any certainty on the slender data at command. It somewhat resembles (so far as can be judged from the section) the neater varieties of *S. planulata*, and to this species we have provisionally referred it. Messrs. Parker and Jones have observed the presence of this species in the Lower Lias of Warwickshire, which has been, up to the present, the earliest geological record of the occurrence of the genus.

(?) *CORUNSPIRA INVOLVENS* (REUSS).

There are one or two very small planospiral shells that can be recognised in the transparent slides. Considered morphologically they may belong to one or other of three genera—*Cornuspira* (in which the shell is porcellaneous and imperforate), *Spirallina* (with the test hyaline and perforate), or *Ammodiscus* (an arenaceous foraminifer). The last-mentioned is a common form in the Carboniferous limestone of Europe, from which about eight species have been determined. The analogous form in the Permian-Carboniferous rocks of Tasmania is evidently calcareous in structure, and must therefore be referred to one of the two former genera. The minuteness of the objects and the infiltration of mineral matter, to which they have been subjected, make it most difficult to decide on the existence or absence of perforation in the test. It is probable that, for similar reasons, great uncertainty exists as to the distribution of these respective forms in a fossil condition. They have not always been clearly distinguished by

observers, and it is difficult to say with exactness the respective geological range of the two genera. The oldest record for *Spirallina* is in the Lower Tertiary (or Eocene), and is limited at this horizon to the rocks of South Australia and Victoria, whilst fossils attributed to *Cornuspira* have been noted by several observers in the Liassic rocks of England and the Continent. In Eocene strata, and later, *Cornuspira* is an extremely common form in both hemispheres. *Cornuspira involvens* is the simplest and commonest member of the genus, and, in the absence of any clear evidence of perforation, we think it better to classify the objects under consideration as above.*

NODOSARIA (?) *RADICULA* (LINNÉ).

It is evident from the sections that some *Nodosarian* form is not uncommon in the rock. They have been cut at various angles. When taken in transverse section they exhibit a perfectly circular outline; others are inclined to the plane of the section, and show a limited number of chambers cut obliquely; and in two instances the longitudinal axis of the object and the plane of section have been nearly coincident. As far as can be judged, the test is straight, or nearly so. The best example is shown on Plate X., near the top, where it will be seen that eight rectilineal segments have been included, with a slight indication of a ninth chamber. The segments are sub-globular, tapering, and with slight septal constrictions. These features point to *N. radicula*, to which the species may be provisionally assigned. This species has been already recorded from the Permian of Durham and Germany. The section figured of this form by Mr. Brady ("Carboniferous and Permian-Foraminifera," Pl. X., Fig. 9) from the magnesian limestone (Upper Permian) of Durham agrees very closely with the one reproduced from the Permo-Carboniferous of Tasmania, the line of section through the object in the last-named not being quite so central as in the case of Mr. Brady's figure. Another member of the genus, *N. farcimen*, also possesses a very high antiquity in the geological series, occurring not only in the magnesian limestone of Durham, but was discovered by the author† in the "D. Limestone" (Lower Carboniferous) of Northumberland, in which it was very rare. This is the oldest record for the genus.

Scanty as is the material at our disposal for determining the foraminiferal fauna of the Permo-Carboniferous rocks of Australia, it is of special interest, so far as it goes, as being the first instance in which there has been any record of Palæozoic foraminifera in

* In a letter to me, Mr. Stephens says:—"When breaking up a large block of the rock when I first came across it, a quite perfect foraminifer dropped out, shaped something like a small *Euomphalus*, and about the size of a small pin's head. This, unfortunately, got lost, and I never found another specimen like it." This description applies with great appropriateness to *Cornuspira involvens*.

† "Additions to the Knowledge of Carboniferous Foraminifera," by W. Howchin, F.G.S., Jour. Roy. Micro. Soc., August, 1888. Pl. IX., Fig. 21.

Australian geology. The extraordinary prevalence of *Nubecularia* in the rock—a form which hitherto has been considered more a modern than ancient type of Protozoa—is a notable fact. Moreover, in the Upper Palæozoic rocks of Australia, judging from the Tasmanian evidence, there is an apparent absence of the arenaceous and sub-arenaceous types, which are the characteristic forms of the Carboniferous foraminifera of the Northern Hemisphere, and their places are taken by genera which construct calcareous and hyaline tests, types that are more characteristic of related faunæ of Secondary and Tertiary age. It must, however, be remembered that the data at present are extremely slender on which to base any broad generalisations, and a more extended examination of rocks of this age may bring to light a closer affinity between the foraminiferal fauna of the Upper Palæozoics of the two hemispheres than appears at present.

DESCRIPTION OF PLATES.

The Plates exhibit portions of the transparent sections of the foraminiferal rock magnified twenty-six diameters.

Plate X.

- a. Eight of the more conspicuous sections of *Nubecularia lucifuga*, var. *Stephensi*, var. nov., are marked a. The example in the upper left-hand corner is a flat parasitic form, the rest are investing.
- b. Longitudinal section of *Nodosaria* (?) *radicula*, Linné.
- c. Transverse section of *Spiroloculina* (?) *planulata*, Lamk, passing nearly through the centre of the test.

Plate XI.

- a. Nine of the more conspicuous sections of *N. lucifuga*, var. *Stephensi*, cut at various angles, are marked a.



4.—A CENSUS OF THE FOSSIL FORAMINIFERA OF AUSTRALIA.

By WALTER HOWCHIN, F.G.S.

It is intended by the present paper to tabulate a complete list of the fossil foraminifera of Australia so far as known at present.

Plate X.

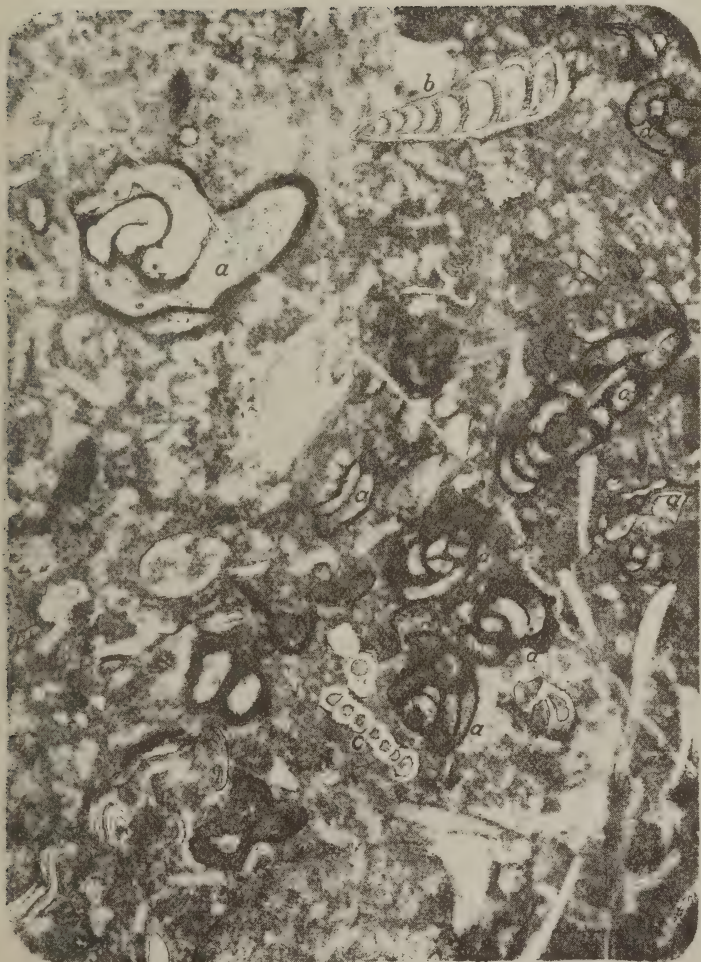


Plate XI.



Many years ago small samples of material from the Lower Tertiaries were examined for foraminifera by the Rev. Tenison Woods, Messrs. Parker and Jones, and Dr. H. B. Brady, particulars of which will be found in the sequel. About ten years ago the author commenced a systematic examination of the microzoal rocks of this continent, with the result that the list of known species of foraminifera in the fossil condition has been greatly increased and many interesting facts bearing upon the distribution of this order in relation to space and time have been collated.

The field of investigation in this department of research is a very wide one, and the methods of observation, demanded by the minuteness of the objects, necessarily slow and tedious. Added to these difficulties is the serious disadvantage of being widely separated from co-workers in the same departments of study and the inaccessibility to works of reference, which is one of the greatest drawbacks to original workers in these colonies. I have to express my grateful acknowledgments to the late Dr. H. B. Brady, F.R.S., Monsieur C. Schlumberger (of Paris), C. D. Sherborn, Esq., F.G.S., F. Chapman, Esq., and others for valuable assistance given in the determination of new and doubtful forms; also to Professor R. Tate, F.G.S., Jas. W. Jones, Esq. (Conservator of Water), John Dennant, Esq., F.G.S., R. Etheridge, jun., Esq. (Government Palæontologist, New South Wales), H. P. Woodward, Esq., F.G.S. (Government Geologist, Western Australia), and many others who have placed geological material at my disposal.

The classification and nomenclature adopted in the present paper are in the main the same as those laid down by Dr. H. B. Brady, in his descriptions of "The Reticularian Rhizopoda of the Challenger Expedition," modified only in a few instances where later researches demand it.

The letters in the columns indicate the relative number of individuals observed whilst searching the material, and have the following values:—V R, very rare; R, rare; R S, rather scarce; M C, moderately common; C, common; V C, very common; X, indicates occurrences when the relative numbers of the species is unknown.

POST-TERTIARY.

Material obtained from elevated sea bed bordering the coast. The Post-Tertiary beds at Port Adelaide are divided into two strongly-marked divisions—an upper bed of bluish sandy clay with shells, and a lower bed of white calcareous sand very full of organic remains. The foraminifera specified below were obtained from the upper bed exposed in the banks of creeks on the Port Adelaide flats. The lower bed has not yet been examined for foraminifera, but large numbers of *Orbitolites complanata*, Lamk., can be easily distinguished in it by the naked eye.

TABLE I.

MILIOLIDÆ.

Nubecularia lucifuga, Deifr.	V C
Miliolina Boueana, d'Orb.	R
circularis, Bornem.	R S
Ferussacii, d'Orb.	R
labiosa, d'Orb.	R
oblonga, Montag.	V C
subrotunda, Montag.	V C
seminulum, Linn.	M C
(Tri.) insignis, Brady	M C
" tricarinata, d'Orb.	V C
" trigonula, Lamk.	R
Spiroloculina excavata, d'Orb.	R
grata, Terq.	M C
Vertebralina striata, d'Orb.	C
Peneroplis pertusus, Forskal	R
planatus, F. & M.	R S

TEXTULARIDÆ.

Textularia conica, d'Orb.	R
Valvulina pupa, MS. Howchin	R
Virgulina pauciloculata, Brady	R
Bolivina punctata, d'Orb.	M C
textilarioides, Rss.	R S
tortuosa, Br.	R

LAGENIDÆ.

Lagena clavata, d'Orb.	R
globosa, Montag.	R
gracillima, Seg.	M C
semistriata, Will.	M C
Polymorphina lactea, W. & J.	R

ROTALIDÆ.

Discorbina globularis, d'Orb.	R
rosacea, d'orb.	R
turbo, d'Orb.	C

ROTALIDÆ—continued.

<i>Discorbina valvulata</i> , d'Orb.	R
<i>vesicularis</i> , Lamk.	V C
<i>Planorbulina Mediterraneensis</i> , d'Orb.	R S
<i>Truncatulina lobatula</i> , W. & J.	R
<i>Rotalia Beccarii</i> , Linn.	R S

NUMMULINIDÆ.

<i>Polystomella crispa</i> , Linn.	V C
<i>macella</i> , F. & M.	R
<i>striato-punctata</i> , F. & M.	V C

The above list contains thirty-eight species, all of which are more or less common in the neighboring Gulf St. Vincent at the present day. Some changes in local distribution are apparent in a few species, particularly those contained in the calcareous bed of the lower division. In the latter bed *Orbitolites complanata* is the prevailing foraminifer. This species is still living on some portions of the Australian coast, but has apparently become extinct in the adjoining waters within recent times.

PLIOCENE.

A bore put down by the Dry Creek Smelting Company about six miles north of Adelaide yielded artesian water at a depth of 320ft. The water stratum proved to be a white quartzose sand of marine origin and very fossiliferous. On the determination of Professor Ralph Tate the mollusca have a facies that can be most appropriately referred to the Pliocene—a marine formation of this age being unique for Australia. On examination, the following species of foraminifera were noted:—

TABLE II.

MILIOLIDÆ.

<i>Biloculina bulloides</i> , d'Orb.	V R
<i>Miliolina Ferussacii</i> , d'Orb.	R
<i>oblonga</i> , Montag.	R
(Tri) <i>tricarinata</i> , d'Orb.	R

LAGENIDÆ.

<i>Polymorphina oblonga</i> , d'Orb.	R
<i>Sagrina</i> (?) <i>columellaris</i> , Brady	V R

ROTALIDÆ.

<i>Discorbina vesicularis</i> , Lamk.	RS
<i>turbo</i> , d'Orb.	R
<i>Rotalia Beccarii</i> , Linn.	VC

NUMMULINIDÆ.

<i>Polystomella crispa</i> , Linn.	VC
---	----

Only ten species have been recorded at this horizon. The material is of a character not particularly favorable for the presence of foraminifera. *Rotalia Beccarii* and *Polystomella crispa* are the prevailing forms, both of which are characteristic of shallow water conditions.

MIOCENE.

LOCALITIES.

No. 1.—From material collected by Professor Tate from the Murray Cliffs, near the North-West Bend Station. It is a fine sand with a small proportion of argillaceous matter with it. Foraminifera scarce.

No. 2.—A fine reddish sand (similar to No. 1) gathered from beds exposed when cutting foundations for new engine-sheds near the west end of Torrens Lake, Adelaide. The foraminifera are somewhat sparingly distributed through the bed, but as there is little or no infiltration of mineral matter in the chambers they can be easily separated from the material by water.

No. 3.—The upper bed of the Muddy Creek section, near Hamilton, Western Victoria. Material supplied by Mr. J. Dennant.

TABLE III.

Genera and Species. .	1 N.W. Bend.	2 Adelai _d e.	3 Muddy Creek.
MILIOLIDÆ.			
<i>Nubecularia lucifuga</i> , Defr.	—	MC	—
<i>Biloculina bulloides</i> , d'Orb.	—	—	R
<i>depressa</i> , d'Orb.	—	—	RS
<i>elongata</i> , d'Orb.	—	—	R
<i>ringens</i> , Lamk.	—	—	RS
<i>Miliolina agglutinans</i> , d'Orb.	—	—	RS
<i>bicornis</i> , W. & J.	—	—	VR
<i>insignis</i> , Brady	—	R	VR

Table III.—continued.

Genera and Species.	1 N.W. Bend.	2 Adelaide.	3 Muddy Creek.
<i>MILIOLIDÆ—continued.</i>			
<i>Miliolina</i> Linneana, d'Orb.	—	—	R S
oblonga, Montag.	—	—	C
secans, d'Orb.	—	—	R S
seminulum, Linn.	—	R	V C
(Tri) tricarinata, d'Orb.	—	R	R
" trigonula, Lamk.	—	R	R S
<i>Spiroloculina</i> grata, Terq.	—	—	V R
limbata, d'Orb.	—	—	R S
<i>Hauerina</i> intermedia, Howchin	—	—	M C
<i>Vertebralina</i> insignis, Brady	—	—	R
<i>Fabularia</i> Howchini, Schlumb.	—	—	R
<i>Sigmoina</i> sigmoidea, Brady (sp.)	—	—	R
<i>LITUOLIDÆ.</i>			
<i>Lituola</i> nautiloidea, Lamk.	—	—	V R
<i>Placopsilina</i> cenomana, d'Orb.	—	—	V R
<i>TEXTULARIDÆ.</i>			
<i>Textularia</i> agglutinans, d'Orb.	—	V R	—
var. porrecta, Brady ..	—	—	R S
sagittula, Def.	—	—	C
<i>Verneuilina</i> pygmæa, Egger.	—	—	V R
triquetra, Münst.	—	—	R
<i>Clavulina</i> angularis, d'Orb.	—	—	V R
communis, d'Orb.	—	—	V R
<i>Bulimina</i> elegantissima, d'Orb.	—	—	V R
<i>Cassidulina</i> subglobosa, Brady	—	—	V R
<i>LAGENIDÆ.</i>			
<i>Lagena</i> lineata, Will.	—	V R	—
melo, d'Orb.	—	—	V R
sulcata, W. & J.	—	—	V R
<i>Nodosaria</i> (Gland.) æqualis, Rss.	—	—	R
consobrina, d'Orb.	—	—	V R
filiformis, d'Orb.	—	V R	—
(Gland.) lævigata, d'Orb.	—	—	V R
pauperata, d'Orb.	—	—	R
raphanus, Linné	—	—	R
<i>Fronicularia</i> complanata, Def.	—	—	V R
<i>Rhabdognium</i> exsculptum, Howchin	—	—	R
<i>Polymorphina</i> augusta, Egger.	—	M C	—
communis, d'Orb.	—	M C	R S
compressa, d'Orb.	—	—	M C
elegantissima, P. & J.	—	M C	C
elongata, Howchin, M.S.	—	V C	—

Table III. - continued.

Genera and Species.	1 N.W. Bend.	2 Adelaide.	3 Muddy Creek.
<i>LAGENIDÆ—continued.</i>			
<i>Polymorphina gibba</i> , d'Orb.	—	—	R S
<i>lactea</i> , W. & J.	—	R S	R
<i>oblonga</i> , d'Orb.	—	R S	R S
<i>rotundata</i> , Born.	—	—	R
<i>problema</i> , d'Orb.	—	R	—
<i>Uvigerina pygmæa</i> , d'Orb.	—	—	V R
<i>GLOBIGERINIDÆ.</i>			
<i>Globigerina bulloides</i> , d'Orb.	—	—	R
<i>Orbulina universa</i> , d'Orb.	—	—	R S
<i>ROTALIDÆ.</i>			
<i>Spirillina tuberculata</i> , Brady	—	—	V R
<i>Discorbina biconcava</i> , P. & J.	—	M C	R S
<i>globularis</i> , d'Orb.	—	—	R
<i>opercularis</i> , d'Orb.	—	—	R
<i>pileolus</i> , d'Orb.	—	—	R S
<i>rarescens</i> , Brady	—	—	R
<i>rosacea</i> , d'Orb.	—	R	R S
<i>polystomelloides</i> , P. & J.	—	—	R S
<i>turbo</i> , d'Orb.	—	—	V C
<i>vesicularis</i> , Lamk.	—	R S	R
<i>Vilardeboana</i> , d'Orb.	—	R S	M C
<i>Planorbulina Mediterraneensis</i> , d'Orb.	—	R	—
<i>Truncatulina echinata</i> , var. <i>lævigata</i> , Howchin	—	—	R
<i>Haidingerii</i> , d'Orb.	—	—	R
<i>lobatula</i> , W. & J.	—	R	—
<i>reticulata</i> , Czjzek	—	—	R
<i>Ungeriana</i> , d'Orb.	—	—	R S
<i>Anomalina ammonoides</i> , Rss.	—	—	R
<i>Polytrema miniaceum</i> , var. <i>alba</i> , Carter	—	—	V R
<i>Gypsina globulus</i> , Rss.	—	—	R S
<i>vesicularis</i> , P. & J.	—	—	R S
<i>Pulvinulina repanda</i> , F. & M.	—	—	R S
<i>Rotalia Beccarii</i> , Linn.	M C	M C	C
<i>clathrata</i> , Brady	—	—	V C
<i>papillosa</i> , var. <i>compressiuscula</i> , Brady	R	—	—
<i>Calcarina rarispina</i> , d'Orb.	—	—	M C
<i>NUMMULINIDÆ.</i>			
<i>Nonionina depressula</i> , W. & J.	—	R S	R
<i>Polystomella, crispa</i> , Linn.	R	V C	R S
<i>craticulata</i> , F. & M.	—	—	R
<i>macella</i> , F. & M.	—	R S	R S
<i>imperatrix</i> , Brady	—	—	C
<i>striato-punctata</i> , F. & M.	—	R S	R
<i>subnodosa</i> , Munster	—	—	C
<i>Amphistegina, Lessonii</i>	—	—	R S

The Miocenes of South Australia are not particularly rich in foraminifera. They are, for the most part, either closely compacted oyster beds or fine variegated sands that are sparsely fossiliferous. In the Muddy Creek section, however, there is a rich assemblage of forms. Altogether there are eighty-nine species recorded from these localities, including one new species from the Adelaide beds and several from the Muddy Creek upper bed, some of which are of great interest.

[In the course of discussion at the close of the reading of the present paper, in Section C, Mr. Dennant remarked he has since discovered that the material supplied by him (and from which the determinations have been made) had inadvertently got mixed with material from the lower bed (Eocene). In consequence of this fact the above list may require some revision. I had suspected the presence of foreign forms, and rejected a few as "derived" when searching the material.—W. H.]

EOCENE.

LOCALITIES.

1. *Muddy Creek, No. 1.*—The occurrences noted in No. 1 column have been taken from a short list of species published by the late Rev. Julian E. T. Woods "On Some Tertiary Deposits in the Colony of Victoria (Muddy Creek)." (See Quar. Jour. Geo. Soc., 1865, vol. XXI., p. 391.) In this article the author states:—"The foraminifera are large and numerous; indeed one species (*Amphistegina vulgaris*, d'Orb.) is so common that the clay is principally composed of it. Its large lenticular form can be traced in almost every pinch of the debris, and what makes the individuals more conspicuous is that they have all received the ferruginous glaze, which makes them look like little coins. From their numbers the strata may in truth be called an *Amphistegina* bed, similar to that in Vienna, and probably of the same age." Mr. Woods is evidently mistaken in his determination of *Amphistegina* as the leading feature of the foraminiferal fauna at Muddy Creek. *Amphistegina* exists in the Muddy Creek material, but is not nearly so large or numerous as another species, viz., *Nummulites variolaria*, which answers in all respects to Mr. Woods's descriptions, and is evidently the form intended. It is, therefore, really a *Nummulitic* rather than an *Amphistegine* bed. I have taken the liberty of making this correction in Mr. Woods's list.

2. *Muddy Creek, No. 2.*—This list of 164 species was determined by the present author from the very rich material gathered by Mr. Dennant. A goodly number of the species in this list are more or less rare, and were compiled as the result of a careful microscopic examination of the material extending over a period of two years. For further particulars see "The Foraminifera of the Older Tertiary of Australia (No. 1, Muddy Creek, Victoria),"

Trans. Roy. Soc. S.A., 1889, vol. XII., p. 1. A few alterations in the nomenclature have been made in the list as now published, to bring it up to date, and also includes two additional species—*Trillina Howchini*, Sch.—through the industry of Mons. Schlumberger, of Paris, who discovered this new species in a sample of the material sent him,* and *Fabularia Howchini*, Sch., descriptions of which will be found in Trans. Roy. Soc., S.A., vol. XIV., p. 346. Pl. XIII., Figs. 5-8.

3. In January, 1885, Mr. H. Watts, of Melbourne, sent me a few slides of mounted foraminifera for identification, selected by himself from the Lower Tertiary beds of Waurn Ponds, near Geelong. Column 3 in the subjoined table gives the results of the determination. For a note on the occurrence of *Astrorhiza angulosa*, Br., in this series, see Trans. Roy. Soc. S.A., 1885, vol. VIII., p. 160.

4. For the species indicated in the fourth column I am indebted to Mr. R. M. Johnstone, F.L.S., who published a list of the foraminifera of the Eocene beds of Table Cape, Tasmania, in his "Observations with respect to the Nature and Classification of the Rocks of Australia," and the same has been reproduced in his work on "The Geology of Tasmania." In addition to the species indicated in the column below, Mr. Johnstone has noted the presence of the following genera, of which he was unable to determine the specific relationships, viz., *Biloculina*, *Miliolina*, *Cassidulina*, *Polymorphina*, *Orbulina*, *Nonionina*, and *Nummulites*.

5. The Mount Gambier determinations in column 5 were made by Messrs. W. K. Parker and T. Rupert Jones, F.G.S. (See "Foraminifera from the Bryozoan Limestone near Mount Gambier, South Australia," Quar. Jour. Geol. Soc., 1860, vol. XVI., p. 261.)

6. In a letter to the "Geological Magazine," 1876, p. 324, Mr. R. Etheridge, jun., includes a list of foraminifera determined by the late Dr. H. B. Brady, F.R.S., from material secured "in sinking a Government well in the Murray River flats, on the road from the Burra Burra mines to the great bend on the Murray River, about half-way (thirty miles) between the two points named." In this letter the beds are erroneously said to be of Post-Tertiary age. Dr. Brady's list is given in column 6.

7. The material which supplied the forms indicated in this column was obtained from the Government bore put down in the waterworks yard, Kent Town, Adelaide, in 1881. The lithological characteristics of these beds differ considerably from those known on the eastern side of the Mount Lofty Ranges, consisting of brown and greenish argillaceous sands, and are underlain by a series of freshwater beds. Fuller notes on the foraminifera of this section will be found in an article on "The Foraminifera of the Older Tertiary of Australia (No. 2), Kent Town Bore, Adelaide," Trans. Roy. Soc. S.A., 1891, vol. XIV., p. 350.

* "Note sur les Genres *Trillina* et *Linderina*." Bulletin de la Société Géologique de France, 3 série, tome XXI., p. 118, année, 1893.

TABLE IV.

Genera and Species.	1 Muddy Creek.	2 Muddy Creek.	3 Waurin Ponds.	4 Table Cape.	5 Mount Gambier.	6 Murray Flats.	7 Adelaide.
MILIOLIDÆ.							
<i>Biloculina depressa</i> , d'Orb.	—	R S	—	—	—	X	—
<i>elongata</i> , d'Orb.	—	R	—	—	—	X	—
<i>irregularis</i> , d'Orb.	—	R S	—	—	—	—	—
<i>ringens</i> , Lamk.	—	R S	—	—	—	X	R
<i>Miliolina agglutinans</i> , d'Orb.	—	V C	—	—	—	X	—
<i>Brongniartii</i> , d'Orb.	—	R	—	—	—	—	—
<i>Cuvieriana</i> , d'Orb.	—	R S	—	—	—	—	—
<i>Ferussacii</i> , d'Orb.	—	M C	—	—	—	—	R S
<i>Linneana</i> , d'Orb.	—	R S	—	—	—	—	—
<i>oblonga</i> , Montag.	—	M C	—	—	—	X	R S
<i>prisca</i> , Terq.	—	M C	—	—	—	—	—
<i>pygmæa</i> , Rss.	—	M C	—	—	—	—	—
<i>scrobiculata</i> , Brady	—	R	—	—	—	—	—
<i>seminulum</i> , Linn.	X	M C	X	—	—	X	R S
<i>secans</i> , d'Orb.	—	—	—	—	—	X	—
<i>subrotunda</i> , Mont.	—	—	—	—	—	X	—
(<i>Triloc</i>) <i>tricarinata</i> , d'Orb.	—	R S	—	—	—	X	—
<i>trigonula</i> , Lamk.	X	R S	—	—	—	—	R
<i>undosa</i> , Kar.	—	C	—	—	—	—	—
<i>valvularis</i> , Rss.	—	V R	—	—	—	—	—
<i>Pentellina saxorum</i> , d'Orb.	—	M C	—	—	—	—	—
<i>Trillina</i> , Howchini, Schlumb.	—	R S	—	—	—	—	—
<i>Spiroloculina asperula</i> , Kar.	—	R	—	—	—	—	—
<i>affixa</i> , Terq.	—	R S	—	—	—	—	—
<i>canaliculata</i> , d'Orb.	—	—	—	—	—	X	—
<i>grata</i> , Terq.	—	R S	—	—	—	—	—
<i>Cornuspira crassisepta</i> , Brady	—	R	—	—	—	—	—
<i>foliacea</i> , Phil.	—	R S	—	—	—	X	—
<i>invovens</i> , Rss.	—	R S	X	—	—	X	R S
<i>Hauerina compressa</i> , d'Orb.	—	—	—	—	—	X	—
<i>Orbiculina adunca</i> , F. & M.	—	—	X	—	—	—	—
<i>Orbitolites complanata</i> , Lamk.	—	R	—	—	—	X	—
<i>Vertebralina insignis</i> , Brady	—	R	—	—	—	—	—
<i>Articulina sagra</i> , d'Orb.	—	R	—	—	—	—	—
<i>sulcata</i> , Rss.	—	R	—	—	—	—	—
<i>Sigmoilina sigmoidea</i> , Brady, sp.	—	M C	—	—	—	—	—
<i>Tateana</i> , Howchin, sp.	—	M C	—	—	—	—	—
<i>Planispirina exigua</i> , Brady	—	R	—	—	—	—	—
<i>contraria</i> , d'Orb.	—	—	—	—	—	X	—
ASTRORHIZIDÆ.							
<i>Astrorhiza angulosa</i> , Brady	—	—	X	—	—	—	—

Table IV.—continued.

Genera and Species,	1	2	3	4	5	6	7
	Muddy Creek.	Muddy Creek.	Wauri Ponds.	Table Cape.	Mount Gambier.	Murray Flats.	Adelaide.
LITUOLIDÆ.							
Reophax fusiformis, Will.	—	R S	—	—	—	—	—
scorpiurus, Mont.	—	R	—	—	—	—	—
Haplophragmium agglutinans, d'Orb. .	—	V R	—	—	—	—	R
pseudospirale, Will.	—	R S	—	—	—	—	—
sphaeroidiniformis, Br., MS.	—	C	—	—	—	—	—
Bdelloidina aggregata, Carter	—	R	—	—	—	—	—
TEXTULARIDÆ.							
Textularia aspera, Brady	—	C	—	—	—	—	—
agglutinans, d'Orb.	—	R S	—	X	MC	—	MC
var. porrecta, Br.	—	R S	—	—	—	—	—
carinata, d'Orb.	—	V R	—	—	—	—	—
gibbosa, d'Orb.	—	MC	X	—	—	—	R
gramen, d'Orb.	—	R S	—	—	—	—	—
pygmæa	—	—	—	X	MC	—	—
rugosa, Rss.	—	R	—	—	—	—	—
sagittula, Def.	X	V C	X	—	—	—	—
var. fistulosa, Brady	—	R	—	—	—	—	—
Pavonina flabelliformis, d'Orb.	—	V R	—	—	—	—	—
Verneuilina polystropha, Rss.	—	R	—	—	—	—	—
tricarinata, d'Orb.	—	R	—	—	—	—	—
triquetra, Munst.	—	C	—	—	—	—	—
Gaudryina rugosa, d'Orb.	—	R S	—	—	—	—	R
Clavulina angularis, d'Orb.	—	V R	—	—	—	—	—
communis, d'Orb.	—	V R	—	—	—	—	—
Bulimina elegantissima, d'Orb.	—	V R	—	—	—	—	—
obtusa, d'Orb.	—	V R	—	—	—	—	—
pupoides, d'Orb.	—	—	—	—	—	—	R S
pyrula, d'Orb.	—	—	—	—	—	—	MC
Bolivina dilatata, Rss.	—	R	—	—	—	—	—
limbata, Brady	—	R	—	—	—	—	—
punctata, d'Orb.	—	R S	—	—	—	—	R
Cassidulina lævigata, d'Orb.	—	R	—	—	—	—	—
crassa, d'Orb. (oblonga, Rss.)	—	—	—	X	MC	—	—
subglobosa, Brady	—	C	—	—	—	—	R S
Ehrenbergina serrata, Rss.	—	R S	—	—	—	—	—
LAGENIDÆ.							
Lagena globosa, Mont.	—	R	—	—	—	—	—
hexagona, Will.	—	V R	—	—	—	—	R
lævis, Mont.	—	—	—	—	—	—	R
lineata, Will.	—	V R	—	—	—	—	—

Table IV.—continued.

Genera and Species.	1 Muddy Creek.	2 Muddy Creek.	3 Waurn Ponds.	4 Table Cape.	5 Mount Gambier.	6 Murray Flats.	7 Adelaide.
<i>LAGENIDÆ—continued.</i>							
<i>Lagena marginata</i> , W. and B.	—	R	—	—	—	—	R
<i>squamosa</i> , Mont.	—	—	—	—	—	—	R
<i>sulcata</i> , W. & J.	—	R	—	—	—	—	R
<i>Nodosaria affinis</i> , d'Orb.	—	R	—	—	—	—	—
<i>costulata</i> , Rss.	—	V R	—	—	—	—	—
<i>laevigata</i> , d'Orb.	—	R	—	—	—	X	—
<i>multilineata</i> , Borne	—	R S	—	—	—	—	—
<i>obliqua</i> , Linne	—	R	—	—	—	—	R
<i>pauperata</i> , d'Orb.	—	R	—	—	—	—	—
<i>plebia</i> , Rss.	—	V R	—	—	—	—	—
<i>raphanus</i> , Linne	—	R S	—	—	—	—	—
<i>scalaris</i> , Batsch	—	R S	—	—	—	—	R
<i>soluta</i> , Rss.	—	R	—	—	—	—	R
<i>verruculosa</i> , Neugel.	—	—	—	—	—	—	R S
<i>Lingulina carinata</i> , var. <i>seminuda</i> , Batsch	—	V R	—	—	—	—	V R
<i>Marginulina costata</i> , Batsch	—	R S	—	—	—	—	—
<i>Fronicularia complanata</i> , Def.	—	R	—	—	—	—	—
<i>Vaginulina legumen</i> , Linne	—	—	—	—	—	—	R
<i>linearis</i> , Mont.	—	V R	—	—	—	—	—
<i>Cristellaria articulata</i> , Rss.	—	R S	—	—	—	—	—
<i>convergens</i> , Borne	—	V R	—	—	—	—	—
<i>cultrata</i> , Mont.	—	R	—	—	—	—	R
<i>rotulata</i> , Lamk.	—	R	—	—	—	X	—
<i>tricarina</i> , Rss.	—	R	—	—	—	—	—
<i>Polymorphina communis</i> , d'Orb.	—	R S	—	—	—	—	R
<i>dispar</i> , Stache	—	M C	—	—	—	—	—
<i>elegantissima</i> , P. & J.	—	C	X	—	—	—	M C
<i>gibba</i> , d'Orb.	—	M C	—	—	—	—	C
<i>lactea</i> , W. & J.	X	R	—	—	M C	—	R
var. <i>oblonga</i> , Will.	—	V R	—	—	—	—	—
<i>oblonga</i> , d'Orb.	—	V R	—	—	—	—	—
<i>ovata</i> , d'Orb.	—	R	—	—	—	—	—
<i>regina</i> , Br., P. & J.	—	R S	—	—	—	—	R
<i>Uvigerina Canariensis</i> , d'Orb.	—	R S	—	—	—	—	—
<i>angulosa</i> , Will.	—	—	—	—	—	—	R S
<i>Sagrina limbata</i> , Brady	—	V R	—	—	—	—	—
<i>GLOBIGERINIDÆ.</i>							
<i>Globigerina bulloides</i> , d'Orb.	—	V C	X	—	C	—	—
var. <i>triloba</i> , Rss.	—	R S	—	—	—	—	—
<i>helicina</i> , d'Orb.	—	R	—	—	—	—	—
<i>inflata</i> , d'Orb.	—	R S	—	—	—	—	—
<i>Orbulina universa</i> , d'Orb.	—	V C	—	—	—	—	—

Table IV.—continued.

Genera and Species.	1 Muddy Creek.	2 Muddy Creek.	3 Wauru Ponds.	4 Table Cape.	5 Mount Gambier.	6 Murray Flats.	7 Adelaid.
<i>GLOBIGERINIDÆ—continued.</i>							
<i>Pullenia quinqueloba</i> , Rss.	—	—	—	—	—	—	R
<i>sphæroides</i> , d'Orb.	—	—	—	—	—	—	R
<i>Sphæroidina bulloides</i> , d'Orb.	—	MC	—	—	—	—	—
<i>ROTALIDÆ.</i>							
<i>Spirillina decorata</i> , Brady	—	R	—	—	—	—	MC
<i>inæqualis</i> , Brady	—	RS	—	—	—	—	—
<i>limbata</i> , Brady	—	R	—	—	—	—	—
<i>tuberculata</i> , Brady	—	RS	—	—	—	—	MC
<i>Discorbina araucana</i> , d'Orb.	—	R	—	—	—	—	—
<i>Bertheloti</i> , d'Orb.	—	R	—	X	MC	—	—
<i>biconcava</i> , P. & J.	—	R	—	—	—	—	R
<i>cruciformis</i> , Howchin	—	MC	—	—	—	—	—
<i>globularis</i> , d'Orb.	—	RS	—	—	—	—	R
<i>orbicularis</i> , Terq.	—	R	—	—	—	—	—
<i>patelliformis</i> , Brady	—	RS	—	—	—	—	—
<i>polystomelloides</i> , P. & J.	—	VR	—	—	—	—	—
<i>rosacea</i> , d'Orb.	—	RS	—	—	—	—	—
(?) <i>tabernacularis</i> , Brady	—	R	—	—	—	—	—
<i>turbo</i> , d'Orb.	X	RS	—	X	—	—	—
<i>Planorbulina acervalis</i> , Brady	—	VR	—	—	—	—	?VR
<i>larvata</i> , P. & J.	—	MC	—	—	—	—	—
<i>Mediterranensis</i> , d'Orb.	—	R	—	—	—	—	R
<i>Truncatulina echinata</i> , Brady	—	RS	—	—	—	—	—
var. <i>lævigata</i> , Howchin	—	MC	—	—	—	—	—
<i>Haidingerii</i> , d'Orb.	X	RS	—	—	MC	—	—
<i>lobatula</i> , W. & J.	—	RS	—	—	—	X	RS
<i>margaritifera</i> , var. <i>Adelaidensis</i> , Howchin	—	—	—	—	—	—	MC
<i>reticulata</i> , Czizek	—	MC	—	—	MC	X	—
<i>Ungeriana</i> , d'Orb.	—	C	—	—	VC	X	C
<i>variabilis</i> , d'Orb.	—	R	—	—	—	—	—
<i>Anomalina ammonoides</i> , Rss.	—	MC	—	—	—	—	R
<i>polymorpha</i> , Costa	—	R	—	—	—	—	—
<i>rotula</i> , d'Orb.	—	R	—	—	R	—	—
<i>Carpenteria proteiformis</i> , Goës	—	MC	—	—	—	—	—
<i>Polytrema miniaceum</i> , var. <i>alba</i> , Carter	—	MC	—	—	—	—	—
<i>Gypsina globulus</i> , Rss.	—	C	—	—	—	—	—
<i>inherens</i> , Schultze	—	R	—	—	—	—	—
<i>vesicularis</i> , P. & J.	—	C	—	—	—	—	—
<i>Pulvinulina auricula</i> , F. & M.	—	R	—	—	—	—	—
<i>Berthelotiana</i> , d'Orb.	—	RS	—	—	—	—	—
<i>elegans</i> , d'Orb.	—	—	—	—	—	X	—

Table IV.—continued.

Genera and Species.	1 Muddy Creek.	2 Muddy Creek.	3 Waurin Ponds.	4 Table Cape.	5 Mount Gambier.	6 Murray Flats.	7 Adelaide.
<i>ROTALIDÆ—continued.</i>							
<i>Pulvinulina</i> Hauerii, d'Orb.	—	R	—	—	—	—	R
oblonga, Will.	—	R	—	—	—	—	—
Patagonica, d'Orb.	—	R	—	—	—	—	—
Partschiana, d'Orb.	—	R S	—	—	—	—	—
pulchella, d'Orb.	X	C	—	—	—	—	—
repanda, F. & M.	—	V C	—	—	—	—	R
Schreibersii, d'Orb.	—	R S	—	—	—	—	—
semiornata, Howchin.	—	R S	—	—	—	—	—
<i>Rotalia</i> Beccarii, Linn.	—	—	X	—	—	—	—
calcar, d'Orb.	—	R	—	—	—	—	—
clathrata, Brady	—	M C	—	—	—	—	—
orbicularis, d'Orb.	—	—	X	—	—	—	—
papillosa, Brady	—	R	—	—	—	—	—
var. compressiuscula, Brady	—	R	—	—	—	—	—
Soldanii, d'Orb.	—	—	—	—	—	X	R
<i>NUMMULINIDÆ.</i>							
<i>Nonionina</i> depressula, W. & J.	—	R	—	—	—	—	—
stelligera, d'Orb.	—	R S	—	—	—	—	—
umbilicatulæ, Mont.	—	R S	—	—	—	—	—
<i>Polystomella</i> craticulata, F. & M.	—	R	—	—	—	X	—
macella, F. & M.	—	V C	—	—	—	X	—
verriculata, Brady	—	R	—	—	—	—	—
<i>Amphistegina</i> Lessonii, d'Orb.	—	M C	—	—	—	—	—
<i>Orbitoides</i> , dispansus, Sow.	—	R S	—	—	—	—	—
Mantelli, Morton	—	C	—	—	—	—	—
stellata, d'Arch.	—	C	—	—	—	—	—
<i>Operculina</i> complanata, Def.	X	V C	—	—	—	—	—
var. granulosa, Leymerie	—	C	—	—	—	—	—
<i>Nummulites</i> variolaria, Sow.	X*	V C	—	—	—	—	—

The Lower Tertiaries, which have yielded such a profusion of mollusca under the zealous researches of Professor Ralph Tate, have proved relatively quite as rich in their foraminiferal fauna. Of the 187 species in the above Table, no less than 164 species are recorded from the extremely rich beds of Muddy Creek. It is somewhat remarkable that a considerable number of the new species of the *Challenger* expedition are found fossil in the Lower Tertiaries of Australia. So far as the foraminifera can be taken as indicative of bathymetrical and climatic conditions in

* See observations under Muddy Creek, No. 1.

geological times, the present Tables point to a gradual elevation of the sea-bottom in southern Australia, dating from Eocene times, and coincidently with this shallowing of the sea there was apparently a slow lowering of temperature. Taking the Muddy Creek formations for analysis in these particulars, we find the lower bed (Eocene) contains 49 per cent. of shallow water species, and 28 per cent. of those which have a moderately deep, to deep, habitat, whilst in the upper bed (Miocene) the shallow water species reach 58 per cent., and the moderately deep, to deep, forms are reduced to 16 per cent.—a decided change in the fauna in the direction of shallowing conditions. Again, by comparing the lists with regard to climatic distribution, the Eocene beds contain 26 per cent. characteristic of tropical and 33 per cent. of warmer temperate zones; whilst in the Miocene beds the tropical forms are reduced to 18 per cent., and the warmer temperate increased to 35 per cent. In the later Pliocenes and Post-Tertiaries the same tendencies are not only continued but accentuated. It is interesting, as bearing upon this subject, to observe that the author has found several sub-arctic species living in the Port Creek.*

CRETACEOUS.

The Cretaceous beds of central Australia have yielded in various places a remarkable supply of artesian water. For the purpose of tapping these subterranean supplies many bores have been sunk, and it has been chiefly from the cores of the diamond drill thus used that the following species of foraminifera have been obtained.

LOCALITIES.

1. *Hergott, No. 1 Bore*.—The results given in this column were obtained from the examination of material at nine different horizons, ranging from 15ft. from the surface down to 309ft., at which depth the bed-rock was touched. For fuller particulars of this bore, see Roy. Soc. Trans., S. Aus., vol. VIII., 1885, p. 79.

2. *Hergott, No. 2 Bore*.—This bore was put down about 150 yards from the preceding. A very complete series of samples at regular distances of 10ft. have been placed at my disposal by Mr. Jones, the Conservator of Water, and, so far as searched, have yielded the forms now indicated. My examination of the core is incomplete. The occurrences noted were observed at the following depths from the surface in feet, viz., 50ft., 100ft., 120ft., 130ft., 140ft., 150ft., and 210ft.

3. *Tarkaninna Bore*.—This bore is situated on The Clayton, about thirty miles north-east of Hergott. Twenty samples of material were examined, ranging in depth from near the surface down to 1,226ft. The quantities available for examination were,

* "The Estuarine Foraminifera of the Port Adelaide River"—Trans. Roy. Soc. S.A., vol. XIII., 1890, p. 161.

in most instances, very limited. Had the material at command been greater no doubt a much longer list of foraminifera would have been obtained. *Ref.* Roy. Soc. Trans. S.A., vol. xvii., 1893, p. 346.

4. *Mirrabuckinna Bore* is situated about twenty miles north of the head of Lake Torrens, and forty-three miles in a straight line south-west of Hergott. Six samples were examined, included within the geological horizons of 40ft. and 153ft. The foraminifera noted in the Table below were limited in their occurrence to the first 50ft. of the section. Below this level the beds proved to be gypseous and unfossiliferous. *Ref.* Trans. Roy. Soc. S.A., vol. xvii., 1893, p. 346.

5. *William Creek* is situated on the Northern railway, about 125 miles north-west of Hergott. The few foraminifera mentioned in No. 5 column were observed in searching a very small supply of material taken from the heap at mouth of bore that was put down in this locality.

6. *Wilcannia*.—I am indebted to Mr. Dombraine for a small sample from the Wilcannia bore, which on searching yielded a few fragments of *Bigennerina nodosaria*, one of the most characteristic of the Australian Cretaceous foraminifera.

7. *Wollumbilla, Queensland*.—From gatherings made by the late Rev. W. B. Clarke, F.G.S., and published in "Australian Mesozoic Geology and Palæontology," by Mr. Charles Moore, F.G.S., Qy. Jour. Geo. Soc., 1870, xxvi., p. 239; also "Geology and Palæontology of Queensland," by Mr. R. L. Jack, F.G.S., and Mr. R. Etheridge, jun., p. 435. Mr. Moore (*loc. cit.*, p. 231) gives the occurrence of *Cristellaria cultrata*, Mont., in the Mesozoic rocks of Western Australia, but without locality.

TABLE V.

Genera and Species.	1	2	3	4	5	6	7
	Hergott.		Tarkanna.	Mirrabuckinna.	William Creek.	Wilcannia, N.S.W.	Wollumbilla, Queensland.
	No. 1 Bore.	No. 2 Bore.					
ASTORRHIZIDÆ.							
Hyperammina vagans, Brady	R	—	?	—	—	—	—
LITUOLIDÆ.							
Reophax ampullacea, Brady	R	R S	—	—	—	—	—
diffugiformis, Brady	—	V R	—	—	—	—	—
fusiformis, Will.	C	C	R	C	—	—	—
scorpiurus, Montf.	R	R	—	C	—	—	—

Table V.—continued.

Genera and Species.	1		2	3	4	5	6	7
	Hergott.		Tarkaninna.	Mirrabuckinna.	William Creek.	Wilcannia. N.S.W.	Wollumbilla. Queensland.	
	No. 1 Bore.	No. 2 Bore.						
LITUOLIDÆ—continued.								
Haplophragmium agglutinans, d'Orb. . .	RS	RS	R	R	—	—	—	—
æquale, Römer	—	MC	—	—	—	—	—	—
glomeratum, Brady	—	R	—	—	—	—	—	—
Canariense, d'Orb.	RS	MC	R	C	VR	—	—	—
Australis, Howchin, MS.	R	RS	R	—	—	—	—	—
Placopsilina cenomana, d'Orb.	R	—	—	—	—	—	—	—
Thurammina compressa, Brady	R	R	R	—	—	—	—	—
Ammodiscus incertus, d'Orb.	—	MC	—	—	—	—	—	—
Sigmoilina celata, Costa, sp.	—	—	?	MC	—	—	—	—
TEXTULARIDÆ.								
Bigenerina digitata, d'Orb.	R	R	R	—	—	—	—	—
nodosaria, d'Orb.	MC	C	R	—	—	R	—	—
Verneuilina polystropha, Rss.	VR	VR	R	—	—	—	—	—
Gaudryina pupoides, d'Orb.	RS	RS	R	—	—	—	—	—
scabra, Brady	?	—	VR	—	—	—	—	—
siphonella, Rss.	RS	—	R	—	VR	—	—	—
LAGENIDÆ.								
Lagena lævis, Montf.	—	VR	—	—	—	—	—	—
Nodosaria communis, d'Orb.	—	VR	—	—	—	—	—	X
farciensis, Sold.	—	R	—	—	—	—	—	—
pauperata, d'Orb.	—	VR	—	—	—	—	—	—
radicula, Linne	R	R	—	—	—	—	—	—
soluta, Rss.	—	R	—	—	—	—	—	—
subtertenuata, Schwag.	—	VR	—	—	—	—	—	—
Lingulina carinata, d'Orb.	VR	—	—	—	—	—	—	—
Frondicularia complanata, Deifr.	—	R	—	—	—	—	—	—
species	—	VR	—	—	—	—	—	—
Vaginulina legumen, Linn.	R	RS	R	—	RS	—	—	—
linearis, Mont.	—	VR	—	—	—	—	—	—
striata, d'Orb.	—	—	—	—	—	—	—	X
Marginulina costata, Batsch	—	RS	VR	—	—	—	—	—
glabra, d'Orb.	R	MC	R	—	RS	—	—	—
Cristellaria acutiauricularis, F. & M.	—	R	—	—	—	—	—	X
var. longicostata, Moore.	—	—	—	—	—	—	—	X
cassis, F. & M.	—	R	—	—	—	—	—	—
crepidula, F. & M.	—	C	R	—	—	—	—	—
cultrata, Mont., var. radiata, Moore	—	—	—	—	—	—	—	X
gibba, d'Orb.	R	C	R	—	MC	—	—	—
rotulata, Lamk	?	VR	—	—	—	—	—	—
Schloenbachi, Rss.	—	RS	—	—	—	—	—	—

Table V.—continued.

Genera and Species.	1	2	3	4	5	6	7
	Hergott.		Tarkaninna.	Mirrabuckinna.	William Creek.	Wilcattia, N.S.W.	Wollumbilla, Queensland.
	No. 1 Bore.	No. 2 Bore.					
<i>LAGENIDÆ—continued.</i>							
<i>Polymorphina angusta</i> , Egger	—	R S	—	—	—	—	—
<i>lactea</i> , W. & J.	R	R S	—	—	—	—	X
<i>rotundata</i> , Bornem.	—	R	—	—	—	—	—
<i>gibba</i> , d'Orb.	—	—	—	—	—	—	X
<i>ROTALIDÆ.</i>							
<i>Spirillina</i> (?) <i>vivipara</i> , Ehrenb.	—	V R	—	—	—	—	—
<i>margaritifera</i> , Will.	—	V R	—	—	—	—	—
<i>Patellina Jonesii</i> , Howchin, MS.	—	R S	—	—	—	—	—
<i>Discorbina Vilardeboana</i> , d'Orb.	—	C	—	—	—	—	—
<i>Anomalina ammonoides</i> , Rss.	—	R S	R	—	—	—	—
<i>Truncatulina lobatula</i> , W. & J.	—	V R	—	—	—	—	X
<i>Ungeriana</i> , d'Orb.	—	—	—	—	—	—	X
<i>Pulvinulina elegans</i> , d'Orb.	V R	—	R	—	—	—	—
(?) <i>Amphistegina Lessonii</i> , d'Orb.	—	V R	—	—	—	—	—

The marine beds of Secondary age have an immense development throughout the central regions of Australia. The lithological features of this formation are very uniform both in section and in area, and so far as these researches have gone the distribution of the foraminifera in the Australian Cretaceous sea was equally general and uniform. The most remarkable feature in the Table is the unusual proportion of foraminifera with arenaceous tests, there being no less than twenty species belonging to this class out of a total of fifty-six.

UPPER PALÆOZOIC.

Permo-Carboniferous.

Australian foraminiferal material of Palæozoic age, so far as obtained, is of the most scanty description. Only two localities have hitherto yielded examples of these minute forms, and under circumstances not the most favorable for their elucidation. The results, so far as can be determined at present, are contained in the subjoined Table.

LOCALITIES.

No. 1.—The few species indicated in the first column have been determined with some reservation from two transparent rock sections

made by Mr. R. Etheridge, jun., Government Palæontologist of New South Wales, from chippings sent by Mr. Thos. Stephens, F.G.S., of Hobart. Mr. Stephens obtained the foraminiferal rock from an outcrop of Permo-Carboniferous limestone, on the River Piper, in the north-east of Tasmania. *Nubecularia* is the prevailing form, and occurs in the rock in very great numbers. *Ref.* See p. 344 *ante*.

No. 2.—The foraminifera mentioned in the second column of the table, together with some other indeterminate and doubtful forms, were obtained by washing the clayey material out of a few small shells of *Productus* and *Spirifera*, kindly sent me by Mr. H. P. Woodward, Government Geologist of Western Australia. The fossils had been collected by him from the Carboniferous beds on the Irwin River, Western Australia. This bed would doubtless yield a much greater number of species if a larger quantity of material could be treated:—

TABLE VI.

Genera and Species.	1	2
	Tasmania.	Irwin River.
<i>Nubecularia lucifuga</i> , var. <i>Stephensi</i> , Howchin.....	X	—
<i>Spiroloculina</i> (?) <i>planulata</i> , Lamk.....	X	—
<i>Cornuspira involvens</i> , Reuss.....	X	—
“ <i>Schlumbergi</i> , Howchin, MS.....	—	X
<i>Nodosaria</i> (?) <i>radicula</i> , Linné.....	X	—
species	—	X
<i>Fronicularia</i> , species	—	X

This first list of the Palæozoic foraminifera of Australia is of special interest as the oldest fauna of this class of organisms observed in the Southern Hemisphere. The facies of the Australian species differs widely from the foraminifera of the Carboniferous limestone of the opposite hemisphere, in which this group is essentially an arenaceous or sub-arenaceous one, whilst those observed in rocks of this age in Australia are characterised by porcellaneous or hyaline tests. The Australian Palæozoic forms show a closer affinity with the Permian, and more particularly with the Liassic faunæ of the Northern Hemisphere, than they do with the Palæozoic. The Irwin River material contains several new species, which will be described in due course.

VII.—COMPARATIVE TABLE.

No.	Genera and Species.	Post-Tertiary.	Pliocene.	Miocene.	Eocene.	Cretaceous.	Upper Palaeozoic.
FAM. MILIOLIDÆ.							
Sub-Fam. Miliolininæ.							
1	Nubecularia lucifuga, Defr.	X	—	X	—	—	—
2	var. Stephensi, Howchin	—	—	—	—	—	X
3	Biloculina bulloides, d'Orb.	—	X	X	—	—	—
4	depressa, d'Orb.	—	—	X	X	—	—
5	elongata, d'Orb.	—	—	X	X	—	—
6	irregularis, d'Orb.	—	—	—	X	—	—
7	ringens, Lamk.	—	—	X	X	—	—
8	Miliolina agglutinans, d'Orb.	—	—	X	X	—	—
9	Boueana, d'Orb.	X	—	—	—	—	—
10	bicornis, W. & J.	—	—	X	—	—	—
11	Brongniartii, d'Orb.	—	—	—	X	—	—
12	circularis, Bornem.	X	—	—	—	—	—
13	Cuvieriana, d'Orb.	—	—	—	X	—	—
14	Ferussacii, d'Orb.	X	X	—	X	—	—
15	insignis, Brady	X	—	X	—	—	—
16	labiosa, d'Orb.	X	—	—	—	—	—
17	Linneana, d'Orb.	—	—	X	X	—	—
18	oblonga, Montag.	X	X	X	X	—	—
19	prisca, Terq.	—	—	—	X	—	—
20	pygmæa, Rss.	—	—	—	X	—	—
21	scrobiculata, Brady	—	—	—	X	—	—
22	secans, d'Orb.	—	—	X	X	—	—
23	seminulum, Linn.	X	—	X	X	—	—
24	subrotunda, Montag.	X	—	—	X	—	—
25	(Tri) tricarinata, d'Orb.	X	X	X	X	—	—
26	trigonula, Lamk.	X	—	X	X	—	—
27	undosa, Kar.	—	—	—	X	—	—
28	valvularis, Rss.	—	—	—	X	—	—
29	Spiroloculina affixa, Terq.	—	—	—	X	—	—
30	asperula, Kar.	—	—	—	X	—	—
31	canaliculata, d'Orb.	—	—	—	X	—	—
32	excavata, d'Orb.	X	—	—	—	—	—
33	grata, Terq.	X	—	X	X	—	—
34	limbata, d'Orb.	—	—	X	—	—	—
35	(?) planulata, Lamk.	—	—	—	—	—	X
36	Pentellina saxorum, d'Orb.	—	—	—	X	—	—
37	Trillina Howchini, Schlumb.	—	—	—	X	—	—
38	Cornuspira crassisepta, Brady	—	—	—	X	—	—
39	foliacea, Phil.	—	—	—	X	—	—
40	involvens, Rss.	—	—	—	X	—	X
41	Schlumbergi, Howchin, MS.	—	—	—	—	—	X
42	Hauerina compressa, d'Orb.	—	—	—	X	—	—
43	intermedia, Howchin.	—	—	X	—	—	—
44	Vertebralina insignis, Brady	—	—	X	X	—	—

VII.—Comparative Table—continued.

No.	Genera and Species.	Post Tertiary.	Pliocene.	Miocene.	Eocene.	Cretaceous.	Upper Palaeozoic.
FAM. MILIOLIDÆ—continued.							
Sub-Fam. Miliolininæ—continued.							
45	Vertebralina striata, d'Orb.....	X	—	—	—	—	—
46	Articulina sagra, d'Orb.	—	—	—	X	—	—
47	sulcata, Rss.	—	—	—	X	—	—
48	Fabularia Howchini, Schlumb.....	—	—	—	X	—	—
49	Sigmolima sigmoidea, Brady sp.	—	—	X	X	—	—
50	Tateana, Howchin sp.	—	—	—	X	—	—
51	celata, Costa, sp.	—	—	—	—	X	—
52	Planispirina contraria, d'Orb.	—	—	—	X	—	—
53	exigua, Brady	—	—	—	X	—	—
Sub-Fam. Orbitolininæ.							
54	Peneroplis pertusus, Forskal	X	—	—	—	—	—
55	planatus, F. & M.	X	—	—	—	—	—
56	Orbiculina adunca, F. & M.	—	—	—	X	—	—
57	Orbitolites complanata, Lamk.	X	—	—	X	—	—
FAM. ASTORRHIZIDÆ.							
58	Astrorhiza angulosa, Brady	—	—	—	X	—	—
59	Hyperammina vagans, Brady	—	—	—	—	X	—
FAM. LITUOLIDÆ.							
60	Reophax ampullacea, Brady	—	—	—	—	X	—
61	diffugiformis, Brady	—	—	—	—	X	—
62	fusiformis, Will.	—	—	—	X	X	—
63	scorpiurus, Montg.	—	—	—	X	X	—
64	Placopsilina cenomana, d'Orb.	—	—	X	—	X	—
65	Thurammina compressa, Brady	—	—	—	—	X	—
66	Ammodiscus incertus, d'Orb.	—	—	—	—	X	—
67	Haplophragmium agglutinans, d'Orb. ..	—	—	—	X	X	—
68	æquale, Römer	—	—	—	—	X	—
69	Australis, Howchin MS.	—	—	—	—	X	—
70	pseudospirale, Will. ..	—	—	—	X	—	—
71	Canariense, d'Orb.	—	—	—	—	X	—
72	glomeratum, Brady	—	—	—	—	X	—
73	sphæroidiniformis, Br. MS.	—	—	—	X	—	—
74	Lituola nautiloidea, Lamk.	—	—	X	—	—	—
75	Bdeloidina, aggregata, Carter	—	—	—	X	—	—
FAM. TEXTULARIDÆ.							
Sub-Fam. Textularinæ.							
76	Textularia agglutinans, d'Orb.	—	—	X	X	—	—
77	var. porrecta, Brady	—	—	X	X	—	—

VII.—Comparative Table—continued.

No.	Genera and Species.	Post Tertiary.	Pliocene.	Miocene.	Eocene.	Cretaceous.	Upper Palaeozoic.
FAM. TEXTULARIDÆ—continued.							
Sub-Fam. Textularinæ—continued.							
78	Textularia aspera, Brady	—	—	—	X	—	—
79	carinata, d'Orb.	—	—	—	X	—	—
80	conica, d'Orb.	X	—	—	—	—	—
81	gibbosa, d'Orb.	—	—	—	X	—	—
82	gramen, d'Orb.	—	—	—	X	—	—
83	pygmæa	—	—	—	X	—	—
84	rugosa, Rss.	—	—	—	X	—	—
85	sagittula, Def.	—	—	X	X	—	—
86	var. fistulosa, Brady	—	—	—	X	—	—
87	Bigenerina digitata, d'Orb.	—	—	—	—	X	—
88	nodosaria, d'Orb.	—	—	—	—	X	—
89	Pavonina flabelliformis d'Orb.	—	—	—	X	—	—
90	Verneuilina polystropha, Rss.	—	—	—	X	X	—
91	pygmæa, Egger	—	—	X	—	—	—
92	tricarinata, d'Orb.	—	—	—	X	—	—
93	triquetra, Münster	—	—	X	X	—	—
94	Gaudryina pupoides, d'Orb.	—	—	—	—	X	—
95	rugosa, d'Orb.	—	—	—	X	—	—
96	scabra, Brady	—	—	—	—	X	—
97	siphonella, Rss.	—	—	—	—	X	—
98	Valvulina pupa, Howchin, MS.	X	—	—	—	—	—
99	Clavulina angularis, d'Orb.	—	—	X	X	—	—
100	communis, d'Orb.	—	—	X	X	—	—
Sub-Fam. Bulimininæ.							
101	Bulimina elegantissima, d'Orb.	—	—	X	X	—	—
102	obtusa, d'Orb.	—	—	—	X	—	—
103	pupoides, d'Orb.	—	—	—	X	—	—
104	pyrula, d'Orb.	—	—	—	X	—	—
105	Virgulina, pauciloculata, Brady	X	—	—	—	—	—
106	Bolivina dilatata, Rss.	—	—	—	X	—	—
107	limbata, Brady	—	—	—	X	—	—
108	punctata, d'Orb.	X	—	—	X	—	—
109	textilarioides, Rss.	X	—	—	—	—	—
110	tortuosa, Brady	X	—	—	—	—	—
Sub-Fam. Cassidulininæ.							
111	Cassidulina lævigata, d'Orb.	—	—	—	X	—	—
112	crassa, d'Orb.	—	—	—	X	—	—
113	subglobosa, Brady	—	—	X	X	—	—
114	Ehrenbergina serrata, Rss.	—	—	—	X	—	—

VII.—Comparative Table—continued.

No.	Genera and Species.	Post Tertiary.	Pliocene.	Miocene.	Eocene.	Cretaceous.	Upper Palaeozoic.
	FAM. LAGENIDÆ.						
	Sub-Fam. Lageninæ.						
115	<i>Lagena clavata</i> , d'Orb.	X	—	—	—	—	—
116	<i>globosa</i> , Mont.	X	—	—	X	—	—
117	<i>gracillima</i> , Seg.	X	—	—	—	—	—
118	<i>hexagona</i> , Will.	—	—	—	X	—	—
119	<i>lævis</i> , Mont.	—	—	—	X	X	—
120	<i>lineata</i> , Will.	—	—	X	X	—	—
121	<i>marginata</i> , W. & B.	—	—	—	X	—	—
122	<i>melo</i> , d'Orb.	—	—	X	—	—	—
123	<i>semistriata</i> , Will.	X	—	—	—	—	—
124	<i>squamosa</i> , Mont.	—	—	—	X	—	—
125	<i>sulcata</i> , W. & J.	—	—	X	X	—	—
126	<i>Nodosaria affinis</i> , d'Orb.	—	—	—	X	—	—
127	(Gl) <i>æqualis</i> , Rss.	—	—	X	—	—	—
128	<i>communis</i> , d'Orb.	—	—	—	—	X	—
129	<i>consobrina</i> , d'Orb.	—	—	X	—	—	—
130	<i>costulata</i> , Rss.	—	—	—	X	—	—
131	<i>farcimen</i> (Sold)	—	—	—	—	X	—
132	<i>filiformis</i> , d'Orb.	—	—	X	—	—	—
133	(Gl) <i>lævigata</i> , d'Orb.	—	—	X	X	—	—
134	<i>multilineata</i> , Borne.	—	—	—	X	—	—
135	<i>obliqua</i> , Linné	—	—	—	X	—	—
136	<i>pauperata</i> , d'Orb.	—	—	X	X	X	—
137	<i>plebia</i> , Rss.	—	—	—	X	—	—
138	<i>radicula</i> , Linné	—	—	—	—	X	X
139	<i>raphanus</i> , Linné	—	—	X	X	—	—
140	<i>scalaris</i> , Batsch	—	—	—	X	—	—
141	<i>soluta</i> , Rss.	—	—	—	X	X	—
142	<i>subtenuata</i> , Schwag.	—	—	—	—	X	—
143	<i>verruculosa</i> , Neugeb.	—	—	—	X	—	—
144	<i>species</i> ..	—	—	—	—	—	X
145	<i>Lingulina carinata</i> , d'Orb.	—	—	—	—	X	—
146	var. <i>seminuda</i> , Batsch	—	—	—	X	—	—
147	<i>Fronicularia complanata</i> , Def.	—	—	X	—	X	—
148	<i>species</i>	—	—	—	—	X	—
149	<i>species</i>	—	—	—	—	—	X
150	<i>Vaginulina legumen</i> , Linné	—	—	—	X	X	—
151	<i>linearis</i> , Mont.	—	—	—	X	X	—
152	<i>striata</i> , d'Orb.	—	—	—	—	X	—
153	<i>Rhabdogonium exsculptum</i> , Howchin ..	—	—	X	—	—	—
154	<i>Marginulina costata</i> , Batsch	—	—	—	X	X	—
155	<i>glabra</i> , d'Orb.	—	—	—	—	X	—
156	<i>Cristellaria acutiauricularis</i> , F. & M. ..	—	—	—	—	X	—
157	var. <i>longicostata</i> , Moore ..	—	—	—	—	X	—
158	<i>articulata</i> , Rss.	—	—	—	X	—	—
159	<i>cassis</i> , F. & M.	—	—	—	—	X	—

VII.—Comparative Table—continued.

No.	Genera and Species.	Post Tertiary.	Pliocene.	Miocene.	Eocene.	Cretaceous.	Upper Palaeozoic.
FAM. LAGENIDÆ—continued.							
Sub-Fam. <i>Lageninæ</i> —continued.							
160	<i>Cristellaria convergens</i> , Borne	—	—	—	X	—	—
161	<i>crepidula</i> , F. & M.	—	—	—	—	X	—
162	<i>cultrata</i> , Mont.	—	—	—	X	—	—
163	var. <i>radiata</i> , Moore	—	—	—	—	X	—
164	<i>gibba</i> , d'Orb.	—	—	—	—	X	—
165	<i>rotulata</i> , Lamk.	—	—	—	X	X	—
166	<i>Schloenbachii</i> , Rss.	—	—	—	—	X	—
167	<i>tricarinnella</i> , Rss.	—	—	—	X	—	—
Sub-Fam. <i>Polymorphininae</i> .							
168	<i>Polymorphina angusta</i> , Egger.	—	—	X	—	X	—
169	communis, d'Orb.	—	—	X	X	—	—
170	compressa, d'Orb.	—	—	X	—	—	—
171	dispar, Stache.	—	—	—	X	—	—
172	elegantissima, P. & J.	—	—	X	X	—	—
173	elongata, Howchin, M.S.	—	—	X	—	—	—
174	<i>gibba</i> , d'Orb.	—	—	X	X	X	—
175	<i>lactea</i> , W. & J.	X	—	X	X	X	—
176	var. <i>oblonga</i> , Will.	—	—	—	X	—	—
177	<i>oblonga</i> , d'Orb.	—	X	X	X	—	—
178	<i>ovata</i> , d'Orb.	—	—	—	X	—	—
179	<i>regina</i> , Br. P. & J.	—	—	—	X	—	—
180	<i>rotundata</i> , Borne	—	—	X	—	X	—
181	<i>problema</i> , d'Orb.	—	—	X	—	—	—
182	<i>Uvigerina angulosa</i> , Will.	—	—	—	X	—	—
183	<i>Canariensis</i> , d'Orb.	—	—	—	X	—	—
184	<i>pygmæa</i> , d'Orb.	—	—	X	—	—	—
185	<i>Sagrina</i> (P) <i>columellaris</i> , Brady	—	X	—	—	—	—
186	<i>limbata</i> , Brady	—	—	—	X	—	—
FAM. GLOBIGERINIDÆ.							
187	<i>Globigerina bulloides</i> , d'Orb.	—	—	X	X	—	—
188	var. <i>triloba</i> , Rss. ..	—	—	—	X	—	—
189	<i>helicina</i> , d'Orb.	—	—	—	X	—	—
190	<i>inflata</i> , d'Orb.	—	—	—	X	—	—
191	<i>Orbulina universa</i> , d'Orb.	—	—	X	X	—	—
192	<i>Pullenia quinqueloba</i> , Rss.	—	—	—	X	—	—
193	<i>sphaeroides</i> , d'Orb.	—	—	—	X	—	—
194	<i>Sphaeroidina bulloides</i> , d'Orb.	—	—	—	X	—	—
FAM. ROTALIDÆ.							
195	<i>Spirillina decorata</i> , Brady	—	—	—	X	—	—
196	<i>inaequalis</i> , Brady	—	—	—	X	—	—
197	<i>limbata</i> , Brady	—	—	—	X	—	—
198	<i>margaritifera</i> , Will.	—	—	—	—	X	—

VII.—Comparative Table—continued.

No.	Genera and Species.	Post Tertiary.	Pliocene.	Miocene.	Eocene.	Cretaceous.	Upper Palaeozoic.
FAM. ROTALIDÆ—continued.							
199	<i>Spirillina tuberculata</i> , Brady	—	—	X	X	—	—
200	(?) <i>vivipara</i> , Ehrenb.	—	—	—	—	X	—
201	<i>Patellina Jonesii</i> , Howchin, MS.	—	—	—	—	X	—
202	<i>Discorbina Araucana</i> , d'Orb.	—	—	—	X	—	—
203	<i>Bertheloti</i> , d'Orb.	—	—	—	X	—	—
204	<i>biconcava</i> , P. & J.	—	—	X	X	—	—
205	<i>cruciformis</i> , Howchin	—	—	—	X	—	—
206	<i>globularis</i> , d'Orb.	X	—	X	X	—	—
207	<i>opercularis</i> , d'Orb.	—	—	X	—	—	—
208	<i>orbicularis</i> , Terq.	—	—	—	X	—	—
209	<i>patelliformis</i> , Brady	—	—	—	X	—	—
210	<i>pileolus</i> , d'Orb.	—	—	X	—	—	—
211	<i>polystomelloides</i> , P. & J.	—	—	X	X	—	—
212	<i>rarescens</i> , Brady	—	—	X	—	—	—
213	<i>rosacea</i> , d'Orb.	X	—	X	X	—	—
214	(?) <i>tabernacularis</i> , Brady	—	—	—	X	—	—
215	<i>turbo</i> , d'Orb.	X	X	X	X	—	—
216	<i>valvulata</i> , d'Orb.	X	—	—	—	—	—
217	<i>vesicularis</i> , P. & J.	X	X	X	—	—	—
218	<i>Vilardeboana</i> , d'Orb.	—	—	X	—	X	—
219	<i>Planorbulina acervalis</i> , Brady	—	—	—	X	—	—
220	<i>larvata</i> , P. & J.	—	—	—	X	—	—
221	<i>Mediterranensis</i> , d'Orb.	X	—	X	X	—	—
222	<i>Truncatulina echinata</i> , Brady	—	—	—	X	—	—
223	var. <i>lævigata</i> , Howchin.	—	—	X	X	—	—
224	<i>Haidingerii</i> , d'Orb.	—	—	X	X	—	—
225	<i>lobatula</i> , W. & J.	X	—	X	X	X	—
226	<i>margaritifera</i> , var. <i>Ade-</i> <i>laidensis</i> , Howchin	—	—	—	X	—	—
227	<i>reticulata</i> , Czjzek.	—	—	X	X	—	—
228	<i>Ungeriana</i> , d'Orb.	—	—	X	X	X	—
229	<i>variabilis</i> , d'Orb.	—	—	—	X	—	—
230	<i>Anomalina ammonioides</i> , Rss.	—	—	X	X	X	—
231	<i>polymorpha</i> , Costa	—	—	—	X	—	—
232	<i>rotula</i> , d'Orb.	—	—	—	X	—	—
233	<i>Carpenteria proteiformis</i> , Goës	—	—	—	X	—	—
234	<i>Polytrema minaceum</i> , var. <i>alba</i> ., Carter	—	—	X	X	—	—
235	<i>Gypsina globulus</i> Rss.	—	—	X	X	—	—
236	<i>inherens</i> , Schultze	—	—	—	X	—	—
237	<i>vesicularis</i> , P. & J.	—	—	X	X	—	—
238	<i>Pulvinulina auricula</i> , F. & M.	—	—	—	X	—	—
239	<i>Berthelotiana</i> , d'Orb.	—	—	—	X	—	—
240	<i>elegans</i> , d'Orb.	—	—	—	X	X	—
241	<i>Hauerii</i> , d'Orb.	—	—	—	X	—	—
242	<i>oblonga</i> , Will.	—	—	—	X	—	—
243	<i>Patagonica</i> d'Orb.	—	—	—	X	—	—
244	<i>Partschiana</i> , d'Orb.	—	—	—	X	—	—

VII.—Comparative Table—continued.

No.	Genera and Species.	Post Tertiary.	Pliocene.	Miocene.	Eocene.	Cretaceous.	Upper Palaeozoic.
FAM. ROTALIDÆ—continued.							
245	<i>Pulvinulina pulchella</i> , d'Orb	—	—	—	X	—	—
246	<i>repanda</i> , F. & M.	—	—	X	X	—	—
247	<i>Schreibersii</i> , d'Orb	—	—	—	X	—	—
248	<i>semiornata</i> , Howchin	—	—	—	X	—	—
249	<i>Rotalia Beccarii</i> , Linn.	X	X	X	X	—	—
250	<i>calcar</i> , d'Orb.	—	—	—	X	—	—
251	<i>clathrata</i> , Brady	—	—	X	X	—	—
252	<i>orbicularis</i> , d'Orb	—	—	—	X	—	—
253	<i>papillosa</i> , Brady	—	—	—	X	—	—
254	var. <i>compressiuscula</i> , Brady ..	—	—	X	X	—	—
255	<i>Soldanii</i> , d'Orb	—	—	—	X	—	—
256	<i>Calcarina rarispina</i> , d'Orb	—	—	X	—	—	—
FAM. NUMMULINIDÆ.							
<i>Sub. Fam. Polystomellinæ.</i>							
257	<i>Nonionina depressula</i> , W. & J.	—	—	X	X	—	—
258	<i>stelligera</i> , d'Orb.	—	—	—	X	—	—
259	<i>umbilicatulula</i> , Mont.	—	—	—	X	—	—
260	<i>Polystomella crispa</i> , Linn	X	X	X	—	—	—
261	<i>craticulata</i> , F. & M.	—	—	X	X	—	—
262	<i>macella</i> , F. & M.	X	—	X	X	—	—
263	<i>imperatrix</i> , Brady	—	—	X	—	—	—
264	<i>striato-punctata</i> , F. & M.	X	—	X	—	—	—
265	<i>subnodosa</i> , Münster	—	—	X	—	—	—
266	<i>verruculata</i> , Brady	—	—	—	X	—	—
<i>Sub. Fam. Nummulitinæ.</i>							
267	<i>Amphistegina Lessonii</i> , d'Orb	—	—	X	X	?	—
268	<i>Orbitoides dispansus</i> , Sow.	—	—	—	X	—	—
269	<i>Mantelli</i> , Morton	—	—	—	X	—	—
270	<i>stellata</i> , d'Arch	—	—	—	X	—	—
271	<i>Operculina complanata</i> , Def.	—	—	—	X	—	—
272	var. <i>granulosa</i> , Leymerie ..	—	—	—	X	—	—
273	<i>Nummulites variolaria</i> , Sow.	—	—	—	X	—	—

5.—NOTE ON THE DISTRIBUTION OF THE GRAPTOLITIDÆ IN THE ROCKS OF CASTLEMAINE.

By T. S. HALL, M.A.

The view formerly expressed by many authors who have dealt with the Lower Silurian rocks in Victoria, that it was not possible to sub-divide the series either on lithological or on palæontological grounds, is one that appears improbable if we consider the great thickness that has been ascribed to the beds. It has been stated that the Graptolites, which almost solely constitute the fauna of the deposits, are all to be found throughout the series from base to summit. An examination of the rocks of Castlemaine, however, shows that this is not the case, but that certain forms are characteristic of some localities, while others are found elsewhere. At present I have many species that I am unable to determine specifically, so that I must withhold a detailed discussion till a later date. Of the identifiable forms, however, there are some which range throughout the series, while others afford a ready means of distinguishing certain zones, and I have quite recently been able to determine with certainty the order of succession.

The texture of the rocks has frequently been described, ranging as it does from coarse grits with grains $\frac{1}{2}$ in. in diameter down to fine slates. Slaty cleavage is well developed all over the field, and dips about 80° to the westward. As in Bendigo, the anticlinal folds follow in rapid succession, and I have traced thirteen in two and a quarter miles. The strike is very constant, being about N. 5° W., with an average dip of about 70° . The country is very rugged, though the hills are of no great height.

The lowest beds examined are well seen in Lost Gully, between Chewton and Fryers, the fauna being apparently identical with that of the central area of Bendigo. This zone is characterised by the abundance of *Tetragraptus fruticosus*, which ranges no higher in the series. There are several other peculiar forms, notably *Goniograptus Thureauxi* and *Thamnograptus typus*. Other forms with a wider range also occur, such as *Didymograptus caduceus*, which is small and rare, but which increases in numbers and in size as higher beds are reached. Associated with these are *Tetragraptus quadribrachiatas*, *T. bryonoides*, *Dichograptus sp.*, and *Phyllograptus typus*, which have a somewhat extended range.

These beds are seen in Wattle Gully to be overlain by a series showing a somewhat different fauna. *Tetragraptus fruticosus* has disappeared, and the commonest form is *Didymograptus bifidus*. I have found two other outcrops of this zone on different anticlines to the west, but cannot as yet directly connect it with the fossiliferous beds above it, as a considerable thickness of sandstones and unfossiliferous slates, extending over several anticlines, intervenes.

The next clearly-marked zone above these is well shown at the head of Victoria Gully, and is characterised by the great abundance of *Didymograptus caduceus* and *Phyllograptus typus*. This is seen to be overlain by a set of beds containing *D. caduceus* in still greater relative abundance, but without *Phyllograptus*. These two zones occur repeatedly over the field, both east and west of Wattle Gully, and are readily distinguished, as *Phyllograptus* if present is quickly found, as, owing to the broad extent of its surface, it is easily displayed, even in badly cleaved beds.

Loganograptus Loganii occurs somewhere near this last zone, but I have only a single fragment from a "mullock-heap" in a disturbed locality. Professor M'Coy says it is abundant at one locality here, but I am afraid the spot is built over, and I cannot, therefore, state definitely where it comes in.

Taking the fauna as a whole, we have, in the highest beds I have examined, what is apparently a *Monograptus*, represented at present by only a single specimen, and related closely to *M. Nilssonii*, the sole difference apparently being the much smaller number of hydrothecæ. *Didymograptus* is represented altogether by about six species, *D. caduceus* being taken as a true species. *Tetragraptus* has three species, two (*T. quadribrachiatum* and *T. bryonoides*) ranging throughout, and the latter attaining a larger size in the uppermost beds. The third species, *T. fruticosus*, is confined to the lowest rocks. *Dichograptus* has two species, I think—*D. octobrachiatum* and *D. octonarius*. *Goniograptus* is represented by two species, *G. Thureaui* being confined to the lowest one, while the other species has a more extended range. *Temnograptus* has one species at any rate, though, perhaps, some of the fragments I have may be distinct. It ranges widely. Two species of *Diplograptus* occur, *D. mucronatus* being very common in the highest zone. *Phyllograptus* is represented by perhaps two species, but more specimens of the doubtful form are required. *Dendrograptus* is fairly common, and I do not know how many species may be claimed. *D. divergens* is one, while another closely resembles *D. flexilis*. *Thamnograptus typus* occurs in the lowest zone.

The only other fossils found comprise a single spicule of a silicious sponge and *Lingulocaris M'Coyi* (Eth. Jun.), which is abundant throughout. Other species of allied crustaceans occur, but are always very obscure.

It is interesting to note that the line of strike of the lowest zone passes through what was the richest reefing country in the field. Mr. E. J. Dunn states that the central area of Bendigo is occupied by the lowest rocks exposed, and that where the beds crop out most gold is obtained.

6.—THE GLACIAL DEPOSITS OF THE BACCHUS MARSH DISTRICT.

By GEO. SWEET, F.G.S., and CHAS. C. BRITTLEBANK.

PLATES XII. AND XIII.

The great and general interest that associates around all ancient as well as modern glacial phenomena, and the recent publication of certain articles referring to the above locality which, if they have not already misled students of such phenomena, have created difficulties where none existed, and increased the labor of more cautious observers, and which, it is thought, call for important and speedy modifications, are our reasons for contributing the present paper to this Association.

The district of Bacchus Marsh has, since it was first visited and described by Mr. (afterwards Sir) Richard Daintree, possessed great interest to geologists. Several gentlemen—including the early officers of the Geological Department, Mr. R. Daintree, Mr. (afterwards Sir) A. R. C. Selwyn, the late S. C. Wilkinson, F.G.S., and others, and of the later officers, R. A. F. Murray, F.G.S., E. J. Dunn, and lastly, Messrs. G. Officer and L. Balfour—have written of various parts or features of the district. Of all the early geologists that mentioned this deposit, none found striated stones* till the later officers of the department observed them in the conglomerates near Darley and Bacchus Marsh, and no writers appear to have recognised the close relationship of the sandstone with the conglomerates, or the great development of both.

But the residence in the northern part of this area for the past five years—that known as the Pentland Hills, lying between Bacchus Marsh and the Dividing Ranges—of one of the writers of this paper, Mr. C. C. Brittlebank, has caused this part of the district to receive more particular attention than it had before claimed. He had observed flattened, polished, and striated stones in several parts of the surface beyond the area of the conglomerates, where they had been found previously, and many hundred feet above them, so that, anticipating the excursion of the Field Naturalists' Club of Victoria to the Werribee Gorge, which is formed through these rocks, in October, 1891, he requested that a geologist should be included in the visiting party. Mr. A. J. Campbell, the leader for the occasion, requested the other writer of this paper to go, and he consented, when both writers met in the field. We had not been there long before the whole party were brought up by the observance of the first flattened and striated pebble seen on that occasion, of the kind which has since been found in such abundance. We then commenced and have since continued working together, with the intention of making the results of our investigations known at as early a date as possible, and as much was hinted by the leader

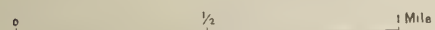
*See R. A. F. Murray's *Geology*, p. 87.

GEOLOGICAL MAP

SHOWING

GLACIAL DRIFT, W. OF BACCHUS MARSH.

Scale—Two Inches to a Mile.



»»» GROOVES AND STRIÆ. ○○ GRAPTOLITES. ○ GANGAMOPTERIS.

○ MIOCENE LEAF AND FRUIT CASTS. ⊕ SCHIZONEURA. CYCADS, &c.

+ GOLD. — FAULT.

GRANITE. SILURIAN. GLACIAL DRIFT.

G.D. 1. CONGLOMERATE.

G.D. 2. SANDSTONES.

G.D. 3. MUDDSTONES.

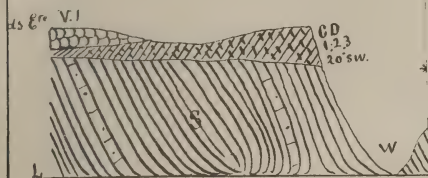
MIOCENE. OLDER BASALT.

NEVEU VOL. POST PLIOCENE. ELVAN. AND BASALTIC DYKES.

NV. PP.

Lines of Sections A-B, C-D, E-F, G-H, I-K, L-M.

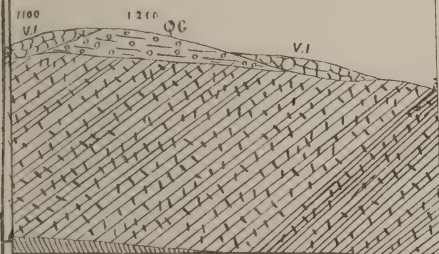
C. D. Dyer, Adelaide.



Section L, M



Section EF on plan



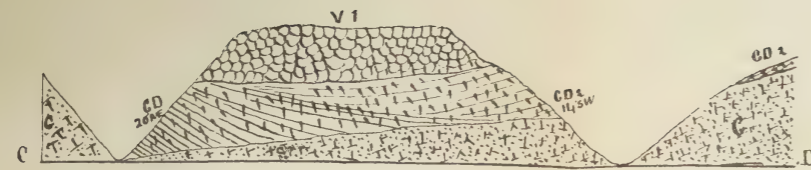
ones. 3 Mudstones. V.1. Newer Volc

rrimul Creek. L, Lerderberg Rang

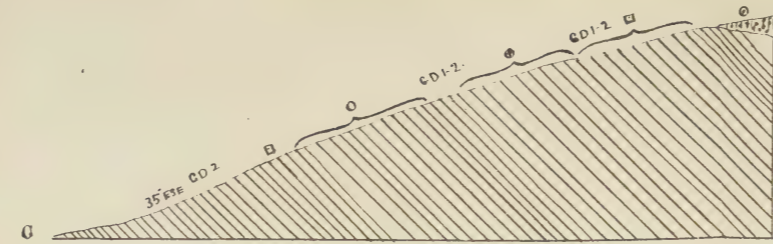
Sections

Glacial Drift

Bacchus Marsh
By
George Sweet FGS & CC Brittlebank.
26.9.93

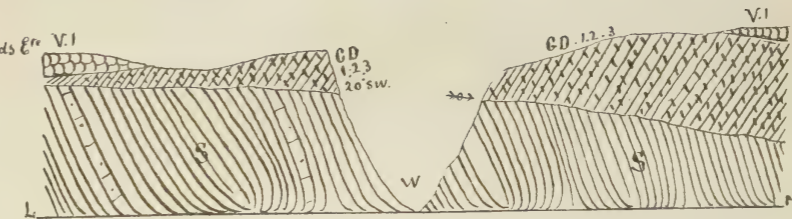


Section CD on plan

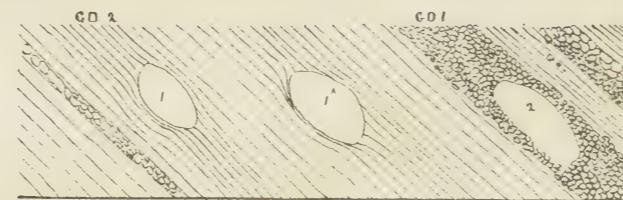


Section GH on plan.

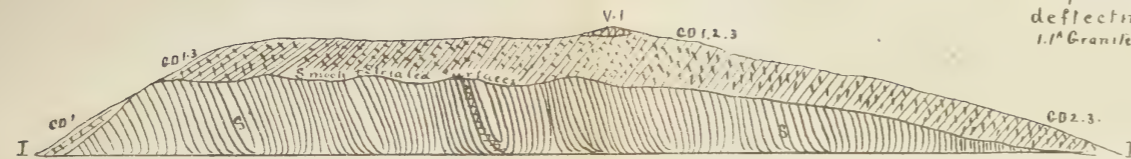
□ Striated stones. ○ Gangamopterus. ⊕ Schizothuria, bryozoa etc.
⊙ Miocene leaf & fruit casts.



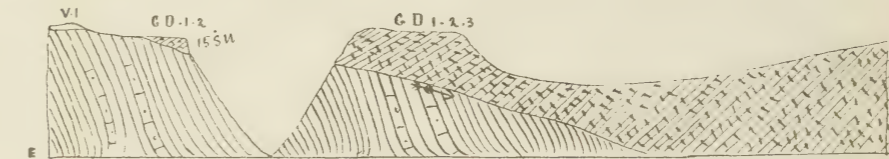
Section LM on plan



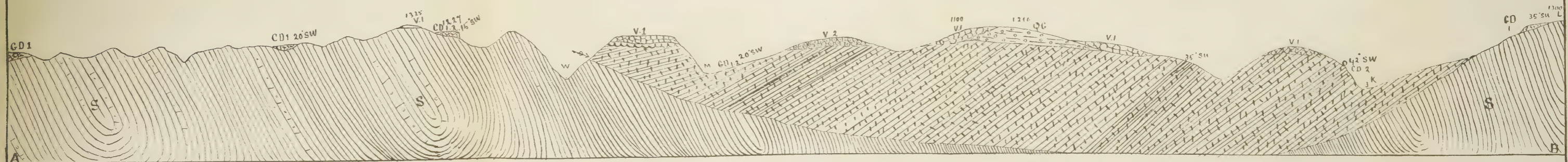
Section of drift showing striated blocks
deflecting bedding planes
1.1^a Granite 2 Silurian



Section IK on plan.



Section EF on plan



Section AB on plan. S. Silurian. G.D. Glacial drift. 1 Conglomerates. 2 Sand stones. 3 Mudstones. V1. Newer Volcanic

V2. Older Volcanic. QG. Quartz Gravel. W. Werribee River. M. Myrning Creek. K. Korkuperrimul Creek. L. Lerderderg Ranges.

of the excursion above referred to in his report to the Field Naturalists' Club.* We soon found, however, that the subject and the locality were such that they could not be fairly dealt with in a hurry, and we concluded it was better to delay publication than give utterance before we had quite digested all the more salient facts. However, we communicated to such fellow-workers as we came in contact with the results of our work; for instance, to Professor R. Tate, in January, 1892, and one of us exhibited several of the striated pebbles at the Field Naturalists' meeting in the same month.†

Shortly after this, on February 5th, 1892, we traced the junction of the deposit with the Silurian rocks, and photographed the site of the first smoothed and scratched rocks discovered. We continued to investigate the subject as opportunity offered, and had concluded that the evidence before us confirmed the general correctness of the opinions of the early geologists concerning the lower conglomerates, for we had obtained in abundance the striated pebbles they failed to find; and we had extended the area over which they were found very far beyond the locality of the conglomerates referred to by them, and into other rocks, viz., the mudstones and sandstones lying to the north-west of those described by Mr. Dunn and others.

In the following June of that year Messrs. Graham Officer, B.Sc., and Lewis Balfour visited the locality for the first time, and on several occasions were conducted over various parts of the area, and shown the chief points of interest then known to us, by one of the present writers, and on July of the same year they read a paper before the Royal Society of Victoria, entitled "A Preliminary Account of the Glacial Deposits of Bacchus Marsh." As this paper treated of a work on which we had been for some nine months previously engaged, and as one of us (Mr. C. C. Brittlebank) had conducted one or more of these writers to many of our first discoveries, and as, further, their conclusions differed so utterly from ours, we still further delayed publication, and reviewed our work, seeking still further evidence, with the result that the further evidence but confirmed our previous conclusions.

Following this a second paper was read in June, 1893, retracting some and very much modifying other contentions of the first paper, but without giving the evidence on which the retraction was made, and still embodying some of the errors of the first. We have therefore concluded to adhere to our first intention, and give the facts as observed by us.

The rocks of which this paper treats have now been traced from a little south of the Ballarat railway line to the Lerderderg Ranges and Mount Blackwood in the north, and from Bacchus Marsh in the south-east to near Ballan in the north-west. Leaving Melbourne, the first point at which these rocks have been observed to

* Vict. Nat., vol. VIII., p. 100. † Vict. Nat. vol. VIII., p. 132.

occur is about thirty miles west—slightly north of a direct west line—extending from east to west thirteen miles and from south to north ten miles; they embrace a total area of 130 square miles. They include (1) the long known stratified “Triassic” sandstones and leaf beds, containing *Gangamopteris*, *Schizoneura*, *Zeugophyllites*, &c.; and on the south and east (2) the conglomerates described and attributed to glacial causes by Mr. R. Daintree, and Sir A. R. C. Selwyn, 1866, and further described by Mr. E. J. Dunn, F.G.S., at the A.A.A.S. meeting in 1890; (3) the so-called older Tertiary boulder-clay or till, and the so-called moraine *profonde*, the supposed two distinct glacial deposits of Messrs. Officer and Balfour. As might be expected, these rocks are not present on the surface of the whole of this area, but the rivers and creeks have eroded their course deep down into and through the upper beds and into the lower, in some places to a depth of over 500ft. Down these slopes and valleys (though it is weary work) examination of the upper, middle, lower, and bed rocks is practicable. The newer rocks met with on the higher summits are the newer and older basalts which cap several of the greater elevations, and have once nearly covered the whole area within the given boundaries. Underneath them we meet with Miocene rocks, containing *Laurus Werribeensis*, &c., and recently we have obtained a considerable variety of fruit casts in the ferruginous sandstones. They lie directly but unconformably on the Triassic sandstones of the earlier geologists, and above the conglomerates of Messrs. Dunn and others, the two latter of which in turn lie directly and unconformably on the almost vertical denuded, deeply grooved, smoothed and striated surfaces (the *roches moutonnées* of Messrs. Officer and Balfour) of the upturned edges of the Silurian rocks, the general direction of the striæ on these surfaces being from S.W. to N.E. In a few places they rest on granite.

We have referred at the beginning of this paper to the junction of these two; this junction has been observed at the following points among many others:—Werribee Gorge, Pike’s Creek, Lerderderg Ranges and River, Korkuperrimul Creek, junction of Werribee and Myrniong creeks, between Parwan Creek and Melbourne and Ballarat line, in cuttings on line; and at nearly all the places where we have been able to remove a portion of the super-incumbent rock from these upturned edges one or more of the features referred to, often all of them—the groovings, striæ, polishings, and occasional very small fractures—have been observed. The groovings are usually in the direction of the strike of the underlying rocks, and form rounded ridges from 3in. or 4in. to double that width and over. When, however, it rests upon granite, as it does at Werribee River and Myrniong Creek, at points about one mile above their junction, fragments of granite are sometimes included in the lower bed, viz., that lying directly on the granite, while at other places the granite has a worn appearance. We

have not, however, observed striae on the granite itself, but in places where the underlying granite has decomposed it has left the imprint of the polished surface and striae on the overlying rock, and these also have a S.W. to N.E. direction. The same remarks apply to the imprint of the striae where the Silurian rock has decomposed from beneath the mudstone or drift, as has also been observed in many places.

The rock immediately reposing on the Silurian and granite base is composed alternately of conglomerate mudstone and sandstone. These are repeated indefinitely, the dip varying from about 10° to 45° , rarely more; they begin south of the Werribee Gorge with a dip of 8° to S.W. and increase to 10° and 14° , and so continue to the main road. From here the basalt overlies the deposit, on the N.E. edge of which the sandstones dip 15° S.W., increasing to 35° and running up to 40° at the Korkuperrimul Creek, and an approximate average dip across the whole area would, we think, be about 25° . These conglomerates are composed of material chiefly derived from various schists and schistose rocks, granites (very many varieties), gneiss, quartz, jasper, porphyry, fine-grained slates, red, dark, pink, gray, and greenish-white quartzites, and indurated sandstones, some containing waterworn quartz pebbles.

The mudstone and sandstone rocks contain a similar assortment of stones and conglomerates, which vary much more in size, from the finest mud to large erratics, though there is generally an arrangement of the material which has classified it somewhat; hence, we have beds of varying grade, of very fine to coarse, and conglomerate, or one merging gradually or suddenly into the other, but all occasionally contain material quite out of the general prevailing assortment of any particular bed. Thus all may contain here and there any sort of stone of any size that is found in any of the beds. Even the most regularly arranged sandstones contain occasional pebbles up to several feet in diameter, and these may be simply waterworn, flattened and striated, faceted, or highly polished and flattened. This is true of the whole of these beds across the whole area and from top to bottom in the sections, as seen in the cliffs and outcrops. There is a fine section to be seen in the cutting near the gate-house No. 24. This appears to be false bedded. Some of the contained stones are 4ft. in diameter; these have deflected the underlying strata; the dip is 15° to 23° S.E. No porphyry or black slate, or indeed any of the rocks such as are to be found close at hand, have been seen in this glacial deposit in any part, except in the case of some granite. South of gate No. 24 there are patches of drift, and the joints run through the beds, cutting through the quartzite boulders, which have not moved since these joints passed through them. Several fine sections are to be seen up the flanks of the Werribee Gorge; some appear to be current bedded; the general dip is to the S.W. The peculiar weathering of some beds give them at the first glance the appear-

ance of being unstratified. The sandstone about here also contains striated stones as well as waterworn pebbles. There is a section one and a half miles up the Korkuperrimul Creek, north of the Big Quarry, dipping 45° S.E., showing for a short distance highly contorted sandstone and clay bands with striated stones; these latter rest on well-stratified sandstones, all 37° S.E. Two miles higher up the creek there is a section of sandstones and mudstone 45° S.W. From here the dip gradually becomes less as we proceed up the creek, the average being 42° S.W., and the beds can be examined consecutively for nearly one mile higher up.

Where the sandstones are overlaid by conglomerate the surfaces of these sandstones are roughened as if by currents; some of the stones are half imbedded in the sandstone. The lowest beds seen in this section are stratified clays containing great numbers of striated stones; these are overlaid by finely stratified sandstones and then conglomerates. Here several basaltic dykes of varying thickness have cut through the beds, and close to the larger dyke a fault occurs; the downthrow is about 95ft., and there are signs of slicken-sides. These faultings do not, however, affect *greatly* the estimate of position and thickness of the beds, which can be followed still further up the same creek for nearly half a mile, where the deposit on this side of the range terminates against the Silurian spur, near to which several *Graptolites* have been obtained by us. From this creek we may cross the Lerderderg Ranges, where outlines of the beds are again seen, and thence across the river of that name. The deposit is again found maintaining its usual characters; on both sides of the Lerderderg River and on the ranges the dip is 35° to S.W. Skirting the river at the head of the cultivated river flats a section of drift is seen forming a river cliff about 50ft. high, the upper beds of which are covered by old river wash. Here the lower part is stratified clay in places, through the whole of which great numbers of striated stones are scattered, some several feet in diameter, and these in some cases have deflected the beds. Following the irrigation channel down the river, at the junction of the Silurian with this deposit are to be seen the grooves and striæ common to nearly all the other localities, running from south to north. Another section is seen about half a mile down stream, on the same side, of fine sandstone and mudstone, with small striated and waterworn stones; the dip is 20° to 25° S.W.

At Goodman's Creek, a tributary of the Lerderderg River, there are sections of drift containing good examples of striated stones and many varieties of granite. Here also the beds of sandstone and mudstone are intercalated, dipping 25° to E.S.E., jointed as at the Werribee Gorge. Returning to the Lerderderg River on the opposite side to that already described, sections of mudstone and sandstone are seen dipping 15° E.S.E. Further up the stream a fine section is exposed, consisting of blue grey clay, stratified and containing numbers of stones, one 5ft. 6in. x 3ft. 6in. x 2ft. 6in.;

this section is capped by the old river bed terrace. The next section up the stream is one of blue-grey clay, with bands of sandstone about 4in. thick running through it; the stratification is very even, except on the south, where a slight bulge upward is seen.

The erosion of these river valleys has been effected since the basaltic overflow, and therefore since the so-called Miocene leaf-beds—which underlie it—were deposited. They could not have existed as valleys at the time of the basaltic overflow, or the viscous mass would have flowed into them, and that being now by far the harder rock, the present valleys would certainly not have been identical with the former ones.

South-west of Dunbar Farm, in the Myrniong Creek, and in the Korkuperrimul Creek from west of the large quarry, occur deposits of basalt that descend to a much lower depth than usual, and occupy what were probably ancient valleys, being over 400ft. in thickness; but the creek sweeps over and around it, or erodes narrow courses only through it, as it forms barriers difficult to erode, and something of this kind would be anticipated wherever the present watercourses approached the ancient valleys which had been filled with the overflow of basalt.

In the paper (referred to above) of Messrs. Officer and Balfour it is mentioned that the first section they examined was situated on the Ballarat-road, about three miles on the Ballarat side of Bacchus Marsh, and is at a height of about 750ft. above the sea, which is some 300ft. higher than the small quarry. They state that the deposit exposed consists of a matrix of clay of a quite unstratified appearance and of a somewhat variable consistency. It is tough and hard in places, while in others it is soft and less tenacious.

This deposit had, previously to those gentlemen visiting it, been examined by ourselves, as also since, and we find that it is stratified and the dip is 25° E.S.E. Its variable consistency, described as being "tough in places, while in others soft and less tenacious," is caused by the denudation of the higher stratified rocks, which have decomposed, and some have fallen down on to the sides of the cutting; so that instead of a Tertiary "till or boulder-clay backed up against stratified siliceous sandstones—really overlying them"—being stamped as of glacial origin by "the unstratified nature of this deposit, together with the peculiar nature and want of arrangement of the included stones," it is rather stamped by these conditions as "talus." We have simply the stratified rock (Triassic sandstones), mudstone, and sandstone, including in its mass boulders of granite (one about 18in. in diameter lying on the road side) and very hard dark-colored quartzite, and the sorts of stone before mentioned, intercalated with beds of pebbly conglomerate. It is the mudstone rock that is exposed here, and the stones are scattered somewhat irregularly and are of various sizes and sorts, round and sub-angular. The angularity of the fragment of sandstone described as occurring in this cutting is caused by

the jointing of a bed of sandstone which runs through the mass, this bed being conformable with the contiguous beds.

An outcrop of white silicious sandstone is noted, and the opinion expressed that "the glacial deposit, *i.e.*, the supposed Tertiary glacial deposit, is banked up against this, really overlying it." This outcrop is a part of the harder beds, while that which is the supposed "glacial deposit backed up against it" is simply surface denuded rock—"talus"—as before described. They also remark as to the unstratified nature of the small cutting in the Lateral-road, not far from this, which is due to similar, though not identical, causes. Mention is also made of the fact that a considerable amount of this material about half a mile up the Myrning Creek from the confluence of the Myrning Creek and Werribee River, about 100ft. in thickness, similar to that described on the Ballarat-road, is exposed, and this, it is said, "consists of a mass of yellowish-white clay, quite unstratified, soft on the weathered surface, but harder on being penetrated." Again, it is stated that "on the other side, to the north of the Myrning Creek, but nearer its junction with the Werribee River, this glacial deposit attains a depth of about 150ft., and can be traced over the brow of the valley to the level of Mr. Brittlebank's house, 350ft. above the creek and about 1,100ft. above the sea. It then spreads out over the surface"—from which they "think it evident that the valley now occupied by the Myrning Creek, at this point at any rate, is a very ancient one, and was at one time probably almost filled up by this Tertiary glacial conglomerate." The observations made by these gentlemen in reference to the position, depth, and composition of the first two of these deposits are approximately correct; but the inference as to their having been deposited by Tertiary glaciers appears to us not to be borne out by the evidence, inasmuch as this valley would seem to have been completely eroded since the newer basaltic overflow; the unstratified material referred to—that at the 100ft. and 150ft. sections—being made up in part by slips and denudations from the stratified rocks, other portions having apparently been deposited by the creek as it eroded its course from side to side on the flanks of the valley and continued to deepen its bed, the river wash referred to in turn also wearing away and rolling down the sides of the valley.

This is proved by the fact that the stones in this unstratified and disarranged material are of the same character as the stratified beds, but that many of its contained stones are more waterworn.

There is also a very much larger number of stones in this material, in proportion to the quantity exposed, than exists in the rocks from which it is derived, because, having lost much of the finer sediment in process of re-deposition, it is generally (excepting in cases of old land slips or creek wash) merely superficial, and in the case of the 100ft. section some of the included stones are angular fragments of the basaltic cap that overlies them. It

will be seen that if this 100ft. bed had been laid down before the basaltic overflow by any cause, glacial or otherwise, it could not include angular fragments of the basaltic sheet that flowed over it subsequent to its deposition, and this it does.

Nor have we as yet observed the basaltic overflow reposing directly upon this unstratified material, although Fig. I. of the section given by these gentlemen makes it appear so, but wherever seen it reposes directly either on the granite, Silurian, the old drift deposits—Triassic sandstones—or on the so-called Miocene leaf-beds, but *not* on this re-deposited material.

And further, these basaltic fragments are found—in places—to increase in number as the basaltic sheet is approached, due, evidently, to the breaking away of the edges of the sheet, which of course gravitates to lower levels along the valley sides among the surface material.

The general characters of the conglomerates, as understood by Messrs. Officer and Balfour, “much incline them to the opinion that they would turn out to be, not an ‘iceberg drift’”—as the eminent geologists before mentioned proclaimed the conglomerates occurring in the S. and E. of the area mapped by us to be, and which we find underlie and are intercalated with the Triassic sandstones—“but in reality till or boulder-clay, in fact the ground moraine of glaciers.”

These characters they sum up to be—First, “the unstratified nature of the clay matrix,” but we have seen that the rocks throughout this area, though sometimes disturbed and contorted *are* unmistakably stratified, so that it is rare that any difficulty is met with in obtaining the strike and amount of dip, and that the only unstratified material to be found is made up of hill wash or talus, river wash, small slips, and denuded material reposing on the flanks and edges of the stratified rocks and some of the conglomerates.

Their second reason for believing this “unstratified” material to be due to a ground moraine is “the number and variety of the included stones.” The stones, however, as has been pointed out, are precisely similar in character to those in the recognised older rocks (Triassic sandstones); and the larger proportionate number of stones occurring on the unstratified surfaces is due to the well-known circumstance that ordinary denuding forces naturally remove the finer materials first, leaving the coarser material behind.

This is even more strikingly shown in the case of material brought down by torrentous rivers, as some of this appears to have been, and this probably accounts for the greater proportionate number of stones occasionally observed both by them and ourselves.

Their third reason is “the striated and glaciated aspect of many of these stones,” but, as they have themselves well observed, “some stones in this material do not retain their striated and

glaciated aspect as well as others." This is probably due to their having been subjected to more exposure and attrition in the course of re-deposition.

And their fourth reason, "the total want of arrangement" of these stones, is precisely what might have been expected from the manner in which they have reached, as we conceive, their present position.

There are also, as has been pointed out, the stratified Miocene leaf-beds which overlie the stratified sandstones and intercalated beds, but we have not found them reposing on this unstratified material nor this material on them. Moreover, this material, in any position, is really of only occasional occurrence, and, except in a very few instances, of small extent and superficial depth, and in these places it is fully accounted for.

Reference is made in the same paper to the "rounded hummocky-looking masses of sandstones" to be seen nearly opposite the 100ft. section, the appearance of which was considered suggestive of glacial action; so we thought when first we saw them from a distance, but found on examination they were *only* suggestive. They state, "it is very probable that the glacial conglomerate not long since covered these rocks and thus protected them during a long period from the effects of weathering." They also say, "the sandstone is just the kind of rock on which the abrading and rounding effect of glacial ice would be well represented." "Certainly," they observe, "striæ and grooves are absent." There is, however, *no* evidence that these small hillocks, lying, as they do, at but small elevations above the present creek, are anything more than isolated patches of the stratified rocks, avoided by the creek and subsequently denuded into rounded form, and they are of such material that they would not retain any impression or even general outline, except a rounded one, for any length of time.

In the Werribee Gorge sections of rocks are seen from 200ft. to 300ft., 400ft. and 500ft. high, and some of the cliffs present faces over 100ft. in vertical height. Mr. Dunn calculated the deposit seen by him at about 100ft. in thickness. He referred to the conglomerates, probably, but in this locality the conglomerates and intercalated beds attain a continuous section of 500ft. in height. This has proved to the writers of the paper in question "the existence of a Triassic sea or lake."

Here we are quite at one with Messrs. Officer and Balfour, but, in our opinion, the *whole* of the rocks were laid down under water. They also consider "that the overlying sandstones are continuous with the surrounding ones." In this latter observation they are again undoubtedly correct. As has been before remarked, the mudstones, conglomerates, and sandstones alternate with each other in repeated succession—now in thick beds, now in thin beds, now highly laminated, then for short distances disturbed and distorted,

with the stratification obscured, and this is repeated over several miles of country in the direction of the dip as well as along the strike. This has been observed and traced in over eighty places. In many parts of what was the softer material the larger stones and boulders have been dropped into it, and produced indentations in the underlying stratum. The same paper mentions a section below the falls of the Werribee Gorge, where the so-called "till" is seen resting on the polished and striated surfaces of the Silurian rock. "This is seen to thin out, forming a wedge-shaped mass, and it is overlaid," it is acknowledged, "by the Triassic rocks." This "wedge-shaped mass" is, in reality, precisely the same class of rock as those reposing upon it, and contains similar striated pebbles. This wedge-shaped mass is at the site where we first found the sandstone, &c., lying unconformably on the Silurian rock, and which we found to be stratified; its layers are parallel with the line of its upper bed, so that they become shorter and shorter as they descend, but are still approximately parallel with the above line. The overlying acknowledged Triassic beds are quite conformable with those in this wedge-like mass. Its wedge shape is due to the fact that it was laid down in a slight trough, whose east or thin end, being nearer the surface of the water and having an inclination to the trough, did not retain the falling *debris* and sediment to the extent of the deeper part. Just as all falling *debris* and sediment gravitates to the lower levels, in moving waters, till the lowest depressions are filled up, so here the deeper part of the hollow was first filled, the layers succeeding each other till the level of the highest point was reached, after which the layers were deposited equally over the whole area, the bottom having become horizontal.

In reference to the ground moraine supposed to have been observed by them, we have been quite unable to detect any variation in the beds reposing on the Upper Silurian rocks as they approach the latter, or any differing material between the two. They continue, to near or at the junction, to be stratified, and do not correspond to the rocks over which, if a moraine *profonde*, they must have passed under great pressure, but agree in their contained material, as also in their stratification, with the rocks above them—the so-called Triassic sandstones.

In that paper it is considered that "it will now be seen that here again are two distinct glacial deposits." One they consider is "overlaid by the Triassic sandstones and conglomerates, and is an ancient 'till' or moraine *profonde*"; the other overlies the Triassic sandstones, and is similar to the lower till, except that it is not so hard, nor so traversed by joints.

They acknowledge (page 54) that "the Triassic rocks and sandstone present in places a very hard texture, somewhat resembling the 'till' below the Triassic rocks"; also that "four miles up the Korkuperrimul Creek from the bridge on the Ballarat-road, in

places, when looked at from one point of view, an appearance of a somewhat irregular stratification can be seen in the conglomerate," but they consider this appearance "due to shearing stresses." This is in the conglomerate, but in small mudbands interbedded between the sandstones which dip conformably with them and the conglomerates, and which underlie and overlie them, one of the writers of this paper has found over fifty laminae to the inch. Higher up the creek they did find in one place "several flattened and striated stones resting on the lower side (not bottom)," and found it "difficult to perceive how icebergs could have deposited stones in this manner." The place to which they refer is a bed of conglomerate conformable with the sandstone; the surface portion has become partially decomposed and the striated stones are found *in situ* on the lower bedding plane of the stratum, which, of course, with a dip of over 40° , would be the present side. These stones, therefore, which they describe as resting on this side are really the lower stones of this conglomerate bed. The fact is they recognise that the Triassic sandstones are stratified, but do not perceive that the interbedded mudstones and conglomerates are also stratified because the bedding planes are not quite so distinct.

They observe that between the large quarry of Triassic sandstones, in which *Gangamopteris* occurs, and the Korkuperrimul Creek below it striated stones are numerous, but apparently have not perceived that some of the boulders come from and are still found embedded in the sandstones themselves, and some of the very hardest quartzites are found in this sandstone still retaining the brilliant polish on their flattened sides, their ends and edges being still rough and subangular; and occasionally also striated stones are found, while the conglomerate overlies it conformably, and is also found in lower beds conformably.

A few hundred yards away they again find "unstratified rocks bearing striated stones." So we find this superficial deposit *is* unstratified, that is to say, the stratification of the rocks from which it has come is obscured by the denuded material from the higher beds, but when this thin mantle of "talus" is removed the dip is 20° N.E. They state also "these rocks are overlaid by very irregularly stratified tumultuous-looking sandstones, and these sandstones," they think, "are simply beds associated with the glacial deposit," and they "found striated stones in them."

These observations agree with our own. The wonder is that they did not see that in this they had a key to the whole of this formation, the only difference being that in some places the evidences have to be sought for more than at others. "At one spot, between the 'big' quarry and the 'small' quarry," they state they found "a loamy matrix in which are scattered angular fragments of soft sandstone in all positions." "This," they say, "rests upon the denuded edges of well-stratified Triassic sand-

stones." This is just so, and is the result of weathering of the same sandstones, "talus," like other beds. "In the small quarry the dip is E.S.E. about 35° . The glacial conglomerate can here be seen in section resting on the sandstone to a depth of about 5ft. This is practically correct; but here again, while they rest *on* the sandstones with a dip of 35° other beds of similar sandstones in turn rest *on them*, and they are all conformable.

"Just below the quarry there is another section at right angles to the former. Here an accumulation of rough, angular, and rounded blocks, up to 2ft. in diameter, is embedded in a loamy matrix overlying soft, stratified clays and shales." Here "angular blocks of sandstone in every conceivable position were mixed up in the ruin," which they consider is proof of the action of a glacier. But this is more probably due to weathering, erosion by waters coming down the hillside, and refilling by talus, and is a very small result to have required a glacier to effect. There is, however, not far from this a stratum of the sandstone, which appears to have been much disturbed as though by some powerful force, and in one of these disturbed places are dropped boulders and stones of various kinds found in the conglomerates above them; one of the granite boulders being nearly 4ft. in diameter, and filling the small indentation, while fragments of the adjacent sandstones have dropped into the places left by the softer beds which have decomposed.

This is considered in the paper referred to as "evidence that a glacier has passed over the surfaces and injected this material, boulders, and all into this fissure," and that the basalt then preserved it till now. This is utterly improbable, however. It is far more probable that the force that produced the contortion of the beds close by also produced the small depression in which the large granite boulder is now found, and perhaps dropped it into its place, or both the cavity and its contents may be accounted for by a comparatively small piece of ice, too heavily laden with the boulder and *debris* in question to float any longer, which sank with its load, and, afterwards melting, left the cavity into which the *debris* now found about it entered; while as to the angular blocks of sandstone, these, we think, have almost certainly come down from the sandstone above them, which here rises suddenly and steeply. Mr. R. M. Johnston, F.L.S., addressing the Royal Society of Tasmania, on June 13th of this year, apparently without any special or particular knowledge of the local physical difficulties in the way of accepting Messrs. Officer and Balfour's conclusions, yet considers them highly improbable, properly suggesting that in attempting to account for the irregularities and "dislocations" in these sandstones the eruptive and disturbing forces of the more recently ejected overlying older and newer basalts should not be overlooked, though, in regard to the small angular blocks of sandstone lying near the surface, extending but

for a few yards, and as in the case under consideration, near an early worked quarry on otherwise locally disturbed surface, we have no need to call in their aid. The above explanations, or perhaps the early operations of the quarrymen, or both, will be ample to account for their presence as found, and, as for the "boulder till," it has been shown that the material mistaken for it is of comparatively small amount, and of superficial character, and this small amount is often on ledges and slopes, where, if it had not recently been placed, it would inevitably and quickly have been dislodged in preference to the lower rock in the supposed ancient valley. So that, instead of there being two classes of unstratified rock here, formed by two systems of glaciers somewhere in the Mesozoic and Tertiary ages, and separated by the Triassic sandstones, we have simply the stratified rock, mudstone, and sandstone (Triassic sandstones), and conglomerates, including in their mass the various classes of rock mentioned above, but much more extensively developed than has hitherto been supposed, for on the estimated average of the dip, examined at about 100 places across the whole area, it would appear that we should be justified in estimating the thickness of this formation at approximately 5,000ft. But, it is stated, "it was probably overflowed by Pliocene basalt, which would be the means of protecting it for a considerable period." Now, it is found here, as at many other places, that where ancient valleys have been filled with basaltic flows these become the most dense and tough, and generally form an almost impregnable barrier to erosion, and places so covered are of all others most likely to keep sealed up any deposits over which they are laid. And, further, though the erosion has certainly been great, if it had been sufficient to have removed every vestige of basalt from valleys where it had been hundreds of feet thick, it would undoubtedly have removed this small amount of easily denuded material.

The evidences appear to us to support—

- I. The reference of the early-noticed conglomerates by the first and able geologists of the Geological Survey of Victoria, and of the present departmental officers, and Mr. Oldham, of the Indian Geological Survey, to their deposition under water by the agency of floating ice near shore, and to their final arrangement by the moving waters.
- II. Also, the theory that the sandstones and mudstones, and other conglomerates intercalated between these, but lying to the north, east, and west of them, including those known as Bacchus Marsh Triassic sandstones, have been laid down under water, and probably belong to the same great deposit, and have resulted from similar causes; the beds now dip in a general southerly direction towards the present sea.

- III. Further, that as far as has yet been observed, these rocks contain no direct evidence of glaciers having passed down these valleys or over this area in Tertiary times, and that there does not exist, so far as has yet been observed by us, a moraine *profonde* to prove the existence of such a glacier moving down this valley from the Dividing Range at any time. It will be remembered that the general direction of the grooves and striae, so far as observed by us, are from S.W. to N.E., or *from* the present sea.

One of the writers of this paper, Mr. Geo. Sweet, speaking for himself, considers the beds with which these sandstones seem to him most comparable are such beds as the Hawkesbury sandstones, and it will be of great interest to ascertain if any relationship in time exists between them and the Cape Otway sandstones, whose thickness, also, as estimated by Dr. A. R. C. Selwyn, closely approximates the estimated thickness of the formations under consideration. Besides these, there are other extensive areas occupied by sandstones in these colonies, whose age is as yet undetermined on account of the absence of fossils; for instance, the Grampian sandstones of Victoria, and these it would be well to compare with those under discussion.



7.—EVIDENCES OF RECENT GLACIATION IN NEW SOUTH WALES.

By E. J. STATHAM.



8.—NOTES ON THE IGNEOUS ROCKS OF SOUTH-WESTERN VICTORIA.

By J. DENNANT, F.G.S., F.C.S.

PLATE XIV.

INTRODUCTION.

In the present paper an outline sketch only is attempted of the eruptive rocks of the county of Dundas and small portions on its margin. This part of Victoria has hitherto been regarded as deficient in mineral riches, and consequently no detailed geological survey of it has been undertaken. Mr. A. R. C. Selwyn visited it when marking out the boundaries of the principal formations in the colony, and his work, so far as it went, was admirable, but was

necessarily wanting in detail. My own traverses of the area have been chiefly along the main roads, and I am not, therefore, able to do more than point out a few inaccuracies in the geological map.

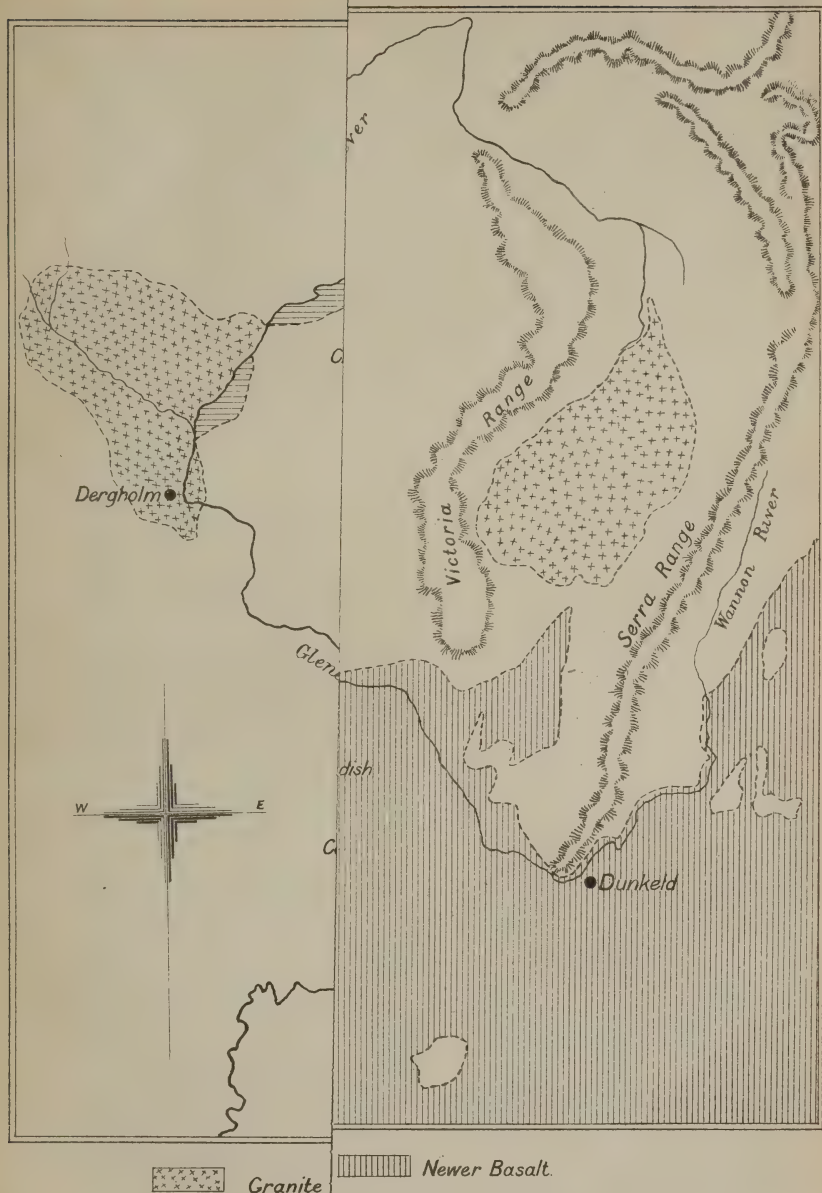
The granites, porphyries, crystalline schists, &c., which form the chief rock masses, vary exceedingly in appearance as well as in structure. Towards the southern and western boundaries of the county especially the rocks present some peculiarity in almost every fresh quarry opened.

The three principal groups of eruptive rocks present in the area will be taken in their order of geological sequence, beginning with the most ancient. A fourth group, viz., the Newer Basalt, which overspreads a great part of Normanby and has invaded the south-eastern limits of Dundas, is so well known that I will not occupy the time of the section by describing it.

PLUTONIC. SEE PLATE XIV.

Granite.—In the geological map of Victoria a central boss of granite is shown in the county of Dundas. In reality, it extends farther north than the map indicates, as for a few miles to the north of the Glenelg, in the neighborhood of Harrow, the hills are composed of this rock; in fact for some distance the river has cut its way through granite. In places to the south also, though its exposures on the surface are infrequent, one is often surprised to find an outcrop of granite here and there. Thus at Carapook a granite outcrop is surrounded by volcanic rocks, and at Coleraine it appears suddenly amongst similar strata. At Wando Vale, near Casterton, a granite hill is surrounded by Mesozoic and volcanic rocks. Again, to the west of the central boss, there are granite outcrops of considerable extent at Tarrayoukyan and Koolomert. On the eastern side the granite extends close to Balmoral, the south road from this town to Harrow being mainly through granite country. On the west of the Glenelg, on the Dergholm to Apsley-road, a smaller boss of granite is marked on the map. This also should be much extended, as it reaches to the river on the east, and beyond Dergholm on the south. Owing to the quantity of drift sand in this region, it is difficult to define the exact limits of the granite. Between the Serra and Victoria Ranges a granite area is also mapped, but the rock is of a different character to that in the other chief localities.

The rocks of the central area are for wide distances covered by Tertiary and recent drifts, so that a detailed geological survey would indicate in some of the localities only strings and apparently isolated patches of granite instead of the unbroken outline of the published map. In places it disappears altogether, and often abruptly. Thus at Wando Dale there is granite on the east of the road, but on the west the River Wando has cut a deep channel through the volcanic surface rocks, and then through the under-





lying crystalline schists. Again at Nareen, though there is granite on the north, west, and east, the fertile land adjoining this picturesque little township consists of decomposed volcanic rocks.

Whenever the county of Dundas is deemed worthy of a detailed geological survey (and I hope the time is not far distant) the outlines, not only of this central boss of granite, but also of the surrounding area of so-called metamorphic rocks, will be materially modified.

Several varieties of granite are met with in different localities. In that from Harrow both biotite and muscovite mica occur. The feldspar is chiefly white orthoclase, but sparingly distributed; there is also a colorless plagioclastic feldspar.

The Carapook granite is similar, but the biotite crystals are much larger; in both they frequently show very perfect basal planes.

The granite of Wando Vale belongs also to the same type, but is finer grained.

The Tarrayoukyan rock is very coarse grained, the crystals of orthoclase being occasionally as much as 15mm. in length. Besides the biotite, which is abundant, there are also small flakes of a light-colored mica. The only specimens of this rock I was able to obtain are a good deal weathered.

The Dergholm granite is porphyritic, with large crystals or combinations of crystals of dark-colored quartz in a coarsely crystalline feldspathic matrix. Biotite and muscovite are both present, but the latter only in small quantities.

The country in which this granite is found is generally flat, and the traveller only realises that he is in a granite region by the numerous "tors" met with along the road. One huge mass shown to me in the bed of the Salt Creek is apparently so poised on the underlying rock as to suggest that the slightest touch would knock it over. Around the "tors" there is only sand, the result of the degradation of the granite itself. It is a friable rock, and the isolated patches now seen are probably remnants only of a much more extensive granitic outcrop.

As said before, the granite in Victoria Valley is of a different type to that in other parts of the area. Mica appears to be entirely absent, and its place is taken by a greenish mineral, which I regard as amphibole. In hand specimens this appears to be scattered through the rock in thin strings, or clustered together in grains. The crystals are also irregularly defined in microscopic slides, but, if small particles of the mineral are detached from the matrix and crushed, the minute grains show, I think, the characteristic forms of amphibole. It melts readily before the blowpipe, and becomes magnetic. Owing probably to its containing a rather high percentage of iron, sections must be ground very thin to render it transparent—in such it shows strong pleochrism. The quartz is full of inclusions. A triangular-shaped face on one of my slides

contains numerous spherulites of chalcedony, each giving a perfect interference cross between crossed nicols. The felspar is orthoclase, and varies in color from white to pink. Twinning on the Carlsbad type is frequent. In texture the rock differs a good deal, in some places being very fine grained and in others quite coarse. I once picked up a specimen prismatic in shape, but have not found this variety *in situ*. Both the quartz and felspar often show well-defined crystal boundaries; in very thin sections there is practically no portion which cannot be resolved.

Among other rocks from the Grampians, Mr. Murray, in his Handbook, speaks of a syenitic porphyry as catalogued by Mr. A. R. Selwyn, in 1868. Whether the particular rock I am describing is the one meant I cannot say, but the name agrees with its mineralogical composition.

Von Cotta, in his "Classification of Rocks," says:—"In distinguishing and naming these transition rocks their geological relations must always to some extent be taken into account." As will presently be shown, a typical quartz-porphyry is very abundant on the west and also to the south of the Victoria Range, and it is difficult to resist the conclusion that the two groups of rocks are closely connected. Though there is no actual junction visible, an outcrop of Grampian sandstone separating them, there seems to be a gradual passage from the more coarsely crystalline rocks of Victoria Valley, through the finer grained variety, to the quartz porphyries of Cavendish, and of the syncline between the Victoria and Dundas Ranges. I wish it to be understood that my remarks on the granite of Victoria Valley apply only to the more southerly outcrop, as I have not examined the northerly one.

On either side of the former the Grampian sandstones dip to the west at from 15° to 20° , but break off abruptly on the eastern escarpment of both the Victoria and Serra Ranges. The Victoria Valley is thus not a syncline, and the short distance between the ranges—about eight miles near Mount Victoria, the most southerly point of the Victoria Range, and less than this a few miles to the north—forbids the assumption that there was ever an anticline with its accompanying synclines between these two similarly dipping ranges. If they were formerly connected the original anticline would not be on the site of this valley, but some distance to the east of the Serra Ranges. It consequently follows that the elevation of the mountain chain must then have far exceeded that of the highest peak in the present Grampians.

The central boss of granite to the west of Dundas Range is surrounded either by later trappean and volcanic rocks or by those ancient crystalline schists which probably form the bedrock over the whole region. Speaking of the last, Mr. Selwyn remarks:—"Little is yet known of the relation of these beds, and whether they represent a series older than Silurian or are some highly metamorphosed lower beds of the Grampian sandstone group is

uncertain." The first hypothesis is probably the correct one. Close to the quartz porphyries on the Balmoral-road there are altered sandstones, but they are quite unlike the crystalline schists. That the latter have no essential connection with either the granites or porphyries is evidenced by their occurrence in localities where the plutonic rocks are unknown.

Quartz-porphyry.—Large porphyritic crystals of orthoclase and quartz occur in this rock, scattered through a very fine-grained matrix. There is also a quantity of fine dusty matter, which remains opaque in thin slides. In color the rock varies from almost white to brown. Its sp. gr. is 2.58, and the percentage of silica is 74.7. Usually the porphyry is found in a fresh condition, but near Cavendish the surface rocks are much decomposed. Towards the northern boundary of the outcrop a rock of a light greenish color, quarried for road metal, is, I think, also a highly decomposed portion of the general mass. In this the porphyritic crystals of felspar have mostly become kaolinised, but in hand specimens a few specks of unaltered quartz are still visible.

The town of Cavendish is built on a blackish-looking rock, of so close-grained a texture that the thinnest possible slides remain to the last quite opaque. It is almost, but not quite, destitute of porphyritic structure. By close observation small crystals of both felspar and quartz may be detected. Though so different in appearance from the porphyries of the neighborhood, it should doubtless be classed as a compact variety of them.

About four miles south-east of Cavendish, on the Dunkeld-road, a small rounded hill, dignified by the name of Mount Cavendish, and marked as basaltic on the geological map, is composed of unaltered typical quartz-porphyry. I have not visited the hills on the east of the Balmoral-road, just north of Cavendish, but from their appearance, as seen at a distance, I have little doubt of their being composed of the same rock.

On the eastern flank of the Dundas Range the porphyries show in a small creek, and present a laminated appearance as if they had been poured forth in sheets. This creek is on land belonging to a selector, who, though he aided me most willingly in my search for outcrops of the rock, has a very poor opinion of it, as he concludes from bitter experience that its occurrence indicates a most unproductive soil.

The boundaries assigned to the Dundas quartz-porphyries on the geological survey map must be considerably extended. Commencing on the north at a point about ten miles south-east of Balmoral, they continue along the syncline of the Victoria and Dundas Ranges down to Cavendish, and for some distance to the south of that township, when they pass under basalt.

Turning to the south and south-west, the outcrop crosses the Wannon at Nigretta Falls, and continues through Bochara, and on

to the Grange Burn close to its junction with Muddy Creek, which is its last appearance to the south. Just opposite a cave on the bank the bed of the Grange Burn is formed of short columns of prismatic quartz-porphry. It is a most picturesque spot, and a favorite picnic resort for the residents of Hamilton, five miles distant.

VOLCANIC. SEE PLATE XIV.

The rocks which next come under consideration are perhaps the most interesting in the whole area. Little notice has been hitherto taken of them, and for convenience sake they are colored in the geological map the same as those just described; the two are, however, essentially different rocks. Owing partly perhaps to original difference in composition, but also to the alteration and decomposition which have taken place, there is much variation in the appearance of the rocks now referred to. A few hand specimens of a Coleraine rock have, I find, been classed as phonolite in the Melbourne Technological Museum, but in geological descriptions of the localities other names have been proposed, as basalt, greenstone, diorite, &c. One of the ingredients of phonolite, viz., sanidine, shows in some of the rocks, but nepheline has not been detected, and from a number of analyses made I conclude that it is absent.

At Carapook, Brit Brit, and Coleraine the rocks are fissile, and split easily into flakes. In one locality near Coleraine some slabs quarried for road metal emitted a ringing sound when struck by the hammer. Near the surface the rocks are frequently decomposed, and even for road metal purposes rather deep quarries are necessary. Ultimately they are converted entirely into kaolin, sometimes gritty, and sometimes of a soft greasy texture. When free from iron, which is often the case, it is quite white, and from the last-mentioned variety small ornaments are made by residents. At Wotong Vale, a few miles north of Coleraine, where the best kaolin is found, a picturesque hill, called the Giant Rock, is little more than a huge mass of kaolin.

At Phoinés, near Carapook, a green-colored rock shows, under the microscope, clusters of small lath shaped, with occasionally broader, crystals of felspar, which is probably sanidine. Accompanying them are numerous magnetite grains, and a brown-colored mineral which suggests decomposed olivine. Fluxion structure is noticeable in thin sections of this rock, as also in some prepared from other varieties.

In a quarry at the back of the Coleraine flour mill the surface rock is white and highly decomposed, but lower down becomes black, compact, and glistening. Under the microscope it is seen to consist of a mass of sanidine crystals, with sharply cut boundaries, most of which are columnar-shaped, but some tabular. The majority of the former, and all of the latter, are traversed by cracks,

but some of the columnar-shaped ones are beautifully clear and pellucid. Many of these remain almost black, even in a thin section; at the edge, where this is thinnest, they become of a faint-green color. There are also magnetite grains, and perhaps a little decomposed olivine.

Behind Mount Koroite, on a hill close to the railway line, a rock is quarried which looks to the eye like a basalt. It is compact, and, though fissile, is less so than the Carapook and Brit Brit rocks. Its specific gravity is 2.87. There is much felspar, some of which is apparently sanidine, and, in addition to other minor ingredients, it contains olivine in good-sized crystals.

At Phoinex, what looks like the same rock (judging from its microscopic structure) has, amongst other varieties, been used in building the station villa. From a heap of stones left over by the masons I noticed two or three varieties of rock, and thought at first that they must have come from different localities. The proprietor, Mr. J. R. McPherson, however, assured me that all were quarried in the paddocks close to the house.

An interesting discovery was made at the Mount Koroite outcrop. Almost at the top of the hill a shallow excavation of a few yards in diameter has disclosed a whitish felspathic tufa, small blocks of which now lie in the hollow. On breaking one of these blocks in two for convenience of transport, impressions of cycads were seen on both the fractured surfaces. Mr. Robert Etheridge, of Sydney, who has kindly examined some of the impressions for me, states, "that very little doubt can exist that the plant is a Mesozoic cycad, called *Otozamites*. It also occurs in the Queensland beds of a like age." It should be mentioned that the sedimentary strata, amongst which these igneous rocks appear, are of acknowledged Mesozoic age.

Rocks of a still more basic character than that at Mount Koroite are also intermingled with the rest in the neighborhood of Coleraine. On the road to the Giant Rock two steeply inclined conical hills, locally known as Adam and Eve, stand close together, and form conspicuous objects in the landscape. They consist of lava, which must have been so viscid when in a molten state that it congealed at once, there being no sign of any flow from either hill. From the blocks of stone I have picked out small fragments of olivine, and in thin sections this mineral appears to be the principal ingredient. The rock is black, and so dense that I have not succeeded in making any section really transparent. Its specific gravity reaches 3. A quarry has been opened at the foot of the lower of the two hills, which, though no distinction is made by residents, I call Eve, but the stone is now almost white, and so much decomposed that no clue is afforded as to its original composition. Conical hills are tolerably numerous around Coleraine, but the others are smooth and clothed with grass, while these two are rugged and almost devoid of vegetation. Allied to

this lava there is a dense, dark, flinty looking stone a mile or two to the west, which in microscopic slides presents a similar appearance.

Outside of the principal area of volcanic rocks another smaller one extends from the Mooree Ford, on the Glenelg, to the township of Chetwynd. At the first-mentioned locality there are two smooth, rounded, conical hills, and at the latter a smaller and more pointed one of a rugged character. All three consist of lava, which, at least from the Chetwynd hill, flowed for a short distance. In composition (judging from its appearance under the microscope) it resembles the Adam and Eve rock. The country is much broken along the line of the formation, and the roads skirt it as far as possible, keeping in the adjoining granite.

At Koolomert Station, about halfway between the eastern and western boundaries of the area, some remarkable rocks are exposed in a quarry on the side of a hill. They are prismatic, and stand in slender vertical columns, loosely cemented together. Some are four and others five sided. They vary very much in thickness, the smallest being about $1\frac{1}{2}$ in. in diameter. With care, prisms fully 2 ft. long can be separated. In the quarry they are much longer than this, but it is difficult to avoid fracturing them when using the necessary tools. Being light colored and gritty, I regarded them at first as sandstone, rendered prismatic by igneous agency. A better explanation can, however, be given. Higher up the hill, and just above the quarry, a basic lava crops out, which, at least in its deeper-seated portions, was evidently prismatic. The prisms are still there, but the rock itself has been greatly altered, and now looks like a sandstone. I am informed on good authority that the same prismatic rock appears on the surface at a short distance to the south of Chetwynd.

Another rock mass has yet to be mentioned, situated a little to the west of the main volcanic area, and separated from it by granite and sedimentary (Mesozoic) strata. About five miles to the north of Casterton, on the road to Chetwynd, the River Wando passes through a gorge between two hills, which are locally called "The Hummocks." They consist of rocks of a vivid green color, and somewhat fissile. Some specimens collected show an asbestiform structure, and others might be called picrolite. In the mass the rock is essentially serpentine, with magnetite grains disseminated through it. A rough analysis made some years ago gave nearly 30 per cent. of magnesia. "The Hummocks" have hitherto, I believe, been considered a portion of the crystalline schists which are conspicuously developed farther north, and also to the north-west. Occurring as they do at no great distance from the lavas of the Chetwynd area, in which olivine is the chief ingredient, I think it not improbable that they are also of volcanic origin, and that their present structure is due to the complete serpentinisation of the abundant olivine they once contained. In reality, these two

hills form an integral part of a low range which extends almost to Casterton on the south, and joins schistose masses on the tableland to the north. At Wayne's Hill, the southern termination of the range, there are two quarries, in one of which the rocks are light colored and much decomposed, but the other contains a coarse iron-stained rock, greenish-colored in fresh fracture, with roughly prismatic cleavage. A thin section of it viewed under the microscope recalls "Hummocks" examples, but in addition to the magnetite there are numerous patches of a green-colored mineral and a few small crystals of partially altered olivine. I may add that among the quartzites and micaceous schists of the tableland just north of "The Hummocks" I have seen isolated outcrops of basic lava, and it is therefore quite possible that not only the northern and western, but all three of the volcanic areas described, may be really continuous. If so the line is a tortuous one and must be followed on foot, and not in a vehicle, which was my usual mode of travelling over the district.

In the foregoing imperfect sketch of the igneous rock masses of south-western Victoria the subject has been treated in a general manner only. Some of the problems presented in this interesting and almost untrodden field will require for their solution patient research both in the field and at home with the microscope.



9.—CONTRIBUTION TO THE STUDY OF VOLCANIC ACTION IN EASTERN AUSTRALIA.

By T. W. E. DAVID, B.A., F.G.S., Professor of Geology, University of Sydney.

PLATE XV.

This short paper is intended to supplement the remarks contained in my Presidential Address to Section C at Hobart last year. The oldest volcanic rocks will be referred to first, and the paper will be confined chiefly to researches made since the Hobart meeting.

In New South Wales eruptive rocks, of an age probably earlier than that of Upper Devonian, have recently been discovered in the Braidwood district by Mr. William Anderson, late Geological Surveyor to the Department of Mines, New South Wales, and Mr. P. T. Hammond, his field assistant. These rocks are described in Mr. Anderson's preliminary report on the Major's Creek and Braidwood districts.* The type locality near Major's Creek, where these rocks are developed, is a hill near Back Creek, about three miles distant from the township of Major's Creek. The

* Annual Report Department of Mines, 1892, p. 121-125.

rocks are essentially quartz-felsites, and an examination of their relation to the associated rocks shows that they are certainly older than the overlying sedimentary strata, and also older than the gold-bearing granite of that district.

In company with Mr. W. Anderson and Mr. E. F. Pittmann, A.R.S.M., I lately examined the locality, and we entirely agreed with Mr. Anderson in his interpretation of the section, the principal features of which are shown on sketch section (Plate XV.). Section 1 represents a mass of quartz-felsite, occupying an area of several square miles. The junction line between it and the overlying sedimentary rocks is an eroded one, and there is no evidence of the felsite having anywhere intruded them.

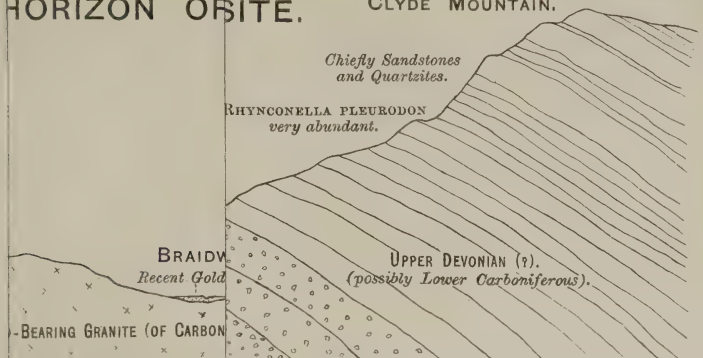
The lowest stratum of the sedimentary rocks is formed of a thick bed of basal conglomerate, composed chiefly of pebbles of quartz-felsite imbedded in a matrix of finer material derived from the disintegration of the same rock. The pebbles composing such portions of this basal conglomerate as have filled in hollows in the eroded surface of the quartz-felsite are coarse, being several inches in diameter. The conglomerate graduates upwards into a reddish grit, with layers of reddish purple shale and grey sandstone, in the first and last of which beds several obscure casts of brachiopods were observed. About 50ft. above the surface of the quartz-felsite *Lepidodendron australe* occurs *in situ* in a bed of grey sandstone, and also in some hard sandy shales on a horizon about 40ft. above the preceding. At the top of the hill, at a total elevation of about 200ft. above the surface of the quartz-felsite, *Lepidodendron australe* was found *in situ* associated with marine fossils, one of which closely resembles *Spirifera disjuncta*.

The dip of these sedimentary rocks is very low, and in places they are nearly horizontal. The whole series of sedimentary rocks is quite conformable, and probably belongs throughout to one period of deposition. This section proves the quartz-felsite to be older than the *Lepidodendron australe* beds with their associated marine fossils. As regards the age of these latter, it is probable that they are referable either to the top of the Devonian or to the base of the Carboniferous series. Lithologically the beds closely resemble the Mount Lambie beds, near Rydal, in New South Wales, which are in part Upper Devonian, and the Avon River sandstones and shales of Victoria, which also contain *Lepidodendron australe*, and which have been doubtfully referred by Mr. R. A. F. Murray, the Government Geologist of Victoria, to the top of the Upper Devonian or to the base of the Carboniferous System.

An examination of the section further to the east in the direction of the Clyde Mountain showed that a series of sedimentary rocks, probably once continuous with those overlying the quartz-felsite near Major's Creek, contained *Rhynchonella pleurodon* in enormous numbers.

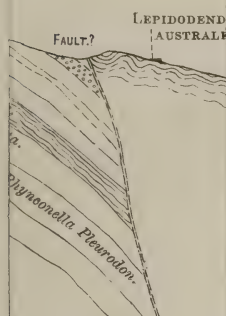
HORIZON ORITE.

CLYDE MOUNTAIN.

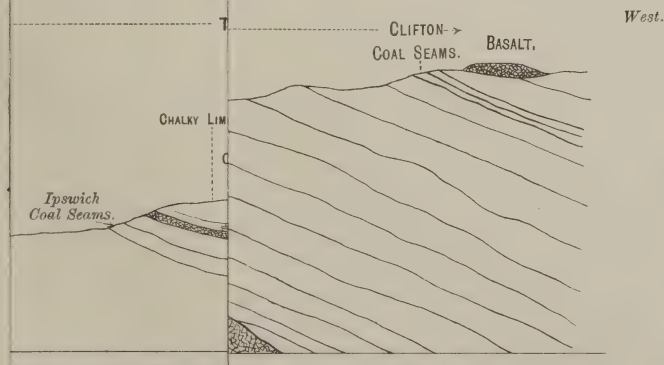


ROCKS WITH

Upper DEVONIAN.



AND OF TES.



At Mount Lambie *Rhynchonella pleurodon* is abundantly associated with *Spirifera disjuncta*, and may therefore be of Upper Devonian age, at the Clyde Mountain, near Braidwood.

Evidence has not yet been obtained as to whether the quartz-felsite of Back Creek, near Major's Creek, is a lava or a plutonic laccolite. Its age is clearly older than either Upper Devonian or Lower Carboniferous.

The possibility suggests itself of this quartz-felsite being homotaxial with the Snowy River porphyries, which are probably of Lower Devonian age, according to A. W. Howitt and R. A. F. Murray. The gold-bearing granite of Braidwood and Major's Creek is of later origin than the quartz-felsite and also than the Upper Devonian (?) sediments, which latter have been much altered and considerably disturbed by the granite. The granite is almost certainly of contemporaneous origin with the gold-bearing hornblendic granites of Hartley and Bathurst, which are later than the Upper Devonian and older than the Permo-Carboniferous (as that term is used in New South Wales), that is, older than the strata containing *Glossopteris*-bearing coal measures associated with a marine fauna, which has affinities partly with the Permian and partly with the Carboniferous of Europe. [The Queensland geologists include under the term Permo-Carboniferous the *Lepidodendron australe* beds occurring in the Star and Gympie Formations in that colony. Beds containing similar fossils in New South Wales are referred either to the Carboniferous or to the top of the Upper Devonian rocks.]

As regards the intrusion of the granite near Braidwood it is interesting to note that it has forced a passage for itself through the outer portion of the earth's crust almost entirely at the expense of some sediments lying to the east of the quartz-felsite, and apparently unconformable to the overlying rocks of Upper Devonian age, whereas it has disturbed the quartz-felsite on its western margin near Back Creek to only a very limited extent. Probably the quartz-felsite resisted the lateral thrust of the granite more successfully than did the sediments.

The purple shales associated with the *Lepidodendron* beds at Back Creek show that lithologically as well as palæontologically they are related to the Upper Devonian at Mount Lambie, for at the latter locality Mr. Pittman and I lately observed that purple shales several hundred feet thick are interstratified with the *Spirifera disjuncta* beds (v. Plate XV., section 2). My field experience in New South Wales has led me to the conclusion that most of such purple shales result from the alteration of fine tuffs, and their presence is therefore an indication of probable contemporaneous volcanic action. Near the Avon River in Victoria the purple shales associated with the *Lepidodendron* beds are evidently related to volcanic rocks, as they are there intimately

associated with sheets of melaphyre, as described by Mr. R. A. F. Murray, Government Geologist of Victoria.*

The quartz-felsites of Rock Creek, whether plutonic or volcanic, are certainly older than the diabasic and felsitic tuffs interstratified with the *Rhacopteris* beds of the Stroud district, in New South Wales, the latter rocks at the time of the meeting of the Association at Hobart being the oldest known representatives of the volcanic division in New South Wales. The credit of this discovery belongs to Mr. W. Anderson, late of the Geological Survey of New South Wales. With the exception of the above felsites no important additions have of late been made to our knowledge of the volcanic rocks of New South Wales, as far as the author is aware. In Queensland Mr. R. L. Jack, F.G.S., the Government Geologist, has supplied me with information, which enables me to make important additions to my previous summary of the volcanic rocks of that colony. In the valley of the Reid thick beds of brecciated volcanic ash are interstratified with Pre-Devonian greywackes. In the Burdekin formation (Devonian) reddish-purple shales are somewhat extensively developed, and may indicate contemporaneous volcanic action. In the Gympie series a chloritic rock with amygdaloidal cavities, probably an "amygdaloidal diabase," has been described by Mr. W. H. Rands. This lava, or tuff, was probably of Carboniferous age. In the *Star* beds (formerly known as the Dotswood beds), probably of Carboniferous age, but grouped under the broad term Permo-Carboniferous, Mr. R. L. Jack has recorded the occurrence of interbedded amygdaloidal porphyrites. In my previous paper due importance was not assigned to the strong evidence of contemporaneous volcanic action at or near the base of the Ipswich coal measures (Triassic) near Brisbane (*v.* Plate XV., section 3). Mr. Jack recently conducted me over a few of the best sections of these volcanic rocks near Brisbane, and I quite concur in the views already expressed by himself and Mr. W. H. Rands, F.G.S., that they are certainly contemporaneous tuffs, probably subaerial. This rock has been well described by Mr. W. H. Rands,† and I cannot do better than quote his description:—"A rock occurs running in a north and south direction through Brisbane. It is a good building stone, and has been employed in most of the principal buildings. . . . It has hitherto been classed as a porphyry, which has been intruded into the micaceous schists. Were this the true nature of the rock one would expect to find the schists in its vicinity altered, in much the same manner that we find them changed to hard lydianised slates, where they border on the granite. No such change is seen, although the junction of this rock with the schists is visible in several cuttings in and about

* Geology and Physical Geography of Victoria, pp. 66-69.

† Report to accompany Geological Map of the City of Brisbane and its Environs, by William H. Rands, Assistant Government Geologist. Government Printer, Brisbane, 1887.

Brisbane. The rock consists of a felspathic matrix with blebs of quartz and some crystals of orthoclase feldspar; its color is generally white or a yellowish-white, though in places it has green, purple, or brown tints. It contains throughout it small particles of micaceous schist and quartz, which towards its base attain the size of pebbles or boulders. It has also near its base pieces of silicified and also of carbonised wood.

Taking into consideration the nature of the rock, its being full of angular particles of other rocks, the absence of any change in the surrounding schists, and, lastly, its position relatively to the other formations, I have come to the conclusion that it is a volcanic ash, and not a porphyry, and that it lies at or near the base of the Ipswich beds." It appeared to me that these tuffs in places must be probably not less than 500ft. thick at Brisbane. Traced in a southerly direction they thin out rapidly. At Corinda, however, a few miles further south-west, the tuffs are replaced by a sheet of amygdaloidal lava of basic or intermediate composition.

Mr. Jack has drawn my attention to the fact that on a much higher horizon in the Ipswich coal measures, and above that of the productive coal seams of Ipswich, a considerable thickness of contemporaneous lavas and volcanic ash are interstratified with the coal measures. Probably at least three groups are represented. The horizon of the principal group is just above that of a strongly-developed sandstone, which Mr. Jack considers may possibly be the equivalent of the Hawkesbury Sandstone of New South Wales. This series is typically developed at Toowoomba. Overlying this volcanic series are the thin coal seams, interbedded with shaly rocks, of Brackets, Gowrie, Jimbour and Clifton.

These may be on the same horizon as the Wianamatta shales of the Sydney coal basin, and may therefore be of Upper Triassic or of Jurassic age, as in Queensland they pass conformably under the Rolling Downs formation (Lower Cretaceous). For the horizon of this volcanic series see "Geology of Queensland," by R. L. Jack and R. Etheridge, jun., Plate XLIX., Fig. 2, to which I am largely indebted for the information on Plate XV., section 3.

Mr. Jack considers the Toowoomba lavas somewhat unconformable to the Ipswich Series both above and below it.

Near Wycarbah, twenty-four miles from Rockhampton, on the Central Railway, tuffs and basaltic rocks are developed homotaxial with some portion of the Ipswich coal measures. In my previous paper I stated that, with the exception of some comparatively insignificant tuffaceous beds in the Desert Sandstone of Queensland, which is considered to be of Upper Cretaceous age, there is no evidence, as far as the author is aware, of contemporaneous volcanic action in Australia in Mesozoic rocks of Jurassic or of Cretaceous age. It is possible, as above suggested, that the Toowoomba basalts may be Jurassic, and the fact should be mentioned that, although the passage just quoted is true generally of the Queens-

land Desert Sandstone, the researches of Mr. Gibb Maitland, Assistant Government Geologist of Queensland, have demonstrated that in the Mackay District there are extensive sheets of sanidine-trachyte and agglomerates referable to the horizon of the Desert Sandstone.

As regards Tertiary volcanic rocks, Mr. Jack distinguishes at least two series—an older and a newer. The series were erupted at a time when the Desert Sandstone had undergone very little denudation, and the newer when the Desert Sandstone had been considerably eroded, as the newer lavas are found filling valleys in the Desert Sandstone.

These two series might be homotaxial with the older volcanic and newer volcanic rocks of the Victorian Survey, the former of which must now be regarded, in part at all events, as Eocene and the latter as Pliocene.

Evidence of the most recent volcanic action in Queensland is observable at the Endeavour River, north of Cooktown, where volcanic necks and traces of craters are well preserved with their radiating sheets of lava. It is doubtful, however, whether even these are newer than Pliocene.

Hot springs, such as those of the Einasleigh River, are the only evidence to show that Queensland still possesses volcanic potentialities. The temperature of the Einasleigh Springs, as described by Mr. Jack, approaches that of boiling point.*

In Victoria the recent researches of Professor R. Tate and Mr. J. Dennant, F.C.S., have facilitated the correlations of the Tertiary volcanic rocks of Victoria with those of New South Wales. In their paper† on correlation of the Marine Tertiaries of Australia these authors have shown that nearly all the so-called Miocene beds, composed chiefly of hard polyzoal limestones, must now be referred to the Eocene Period, and the age of their associated volcanic rocks must therefore be altered correspondingly, and the rocks originally classed as "older volcanic" (Miocene) by the Victorian Survey must be now considered Eocene, and may be homotaxial with the Older Tertiary basalts of New England, which are there associated with a contemporaneous flora considered by Baron Ettingshausen to be Eocene.

The remainder of the Victorian volcanic rocks newer than Eocene are probably either Pliocene or Post-Pliocene. Those which are of Pliocene age are probably approximately homotaxial with the widely-developed Pliocene lavas of New South Wales, which at Gulgong are associated with a contemporaneous flora of Pliocene age, in the opinion of Baron F. von Müller. Remains of *Meiolania*, consisting of a small horn core, the greater part of a caudal vertebra, and two portions of two of the annular segments

* Report of the second meeting of the Australasian Association for the Advancement of Science, 1890, vol. II., p. 458.

† Transactions. Royal Society of South Australia, 1893, p.p. 203-226.

of the tail sheath, have been found in the Canadian Deep Lead, near Gulgong, in drifts, probably on the same horizon as those associated with the basalts at Gulgong, and therefore Pliocene. (On the occurrence of the genus *Meiolania* in the Pliocene Deep Lead at Canadian, near Gulgong, by R. Etheridge, jun., Palaeontologist Records Geological Survey of New South Wales, vol. I., part iii., pp. 149-152.)

In the volcanic geology of Tasmania, as far as I am aware, there have not of late been any important discoveries which necessitate alterations or additions to my previous paper. The fact, however, might be recorded here that subsequent to the Hobart Meeting of the Association I have further examined the so-called diabasic greenstones in the neighborhood of Hobart, in Tasmania, and find them to be gabbros, as suggested by Captain Hutton, the principal constituent minerals being diallage and triclinic felspar with magnetite.

This confirms the conclusion (already in my opinion sufficiently clear upon stratigraphical grounds) that, as maintained by Mr. Thomas Stephens, M.A., the "greenstones" of Hobart are intrusive masses, probably of the nature of laccolites, which are certainly of newer age than either the Permo-Carboniferous rocks of Hobart, or than the Mesozoic coal measures of Newtown, Jerusalem, Fingal, &c.

It remains to summarise briefly the evidence bearing on the questions discussed in my former paper as to whether volcanic action was, in Australia, directly related to heavy sedimentation.

The newly-discovered quartz-felsites of Back Creek do not as yet afford evidence of any value, the conditions relating to their development not yet having been determined. The felsitic tuff bed at the base of the Ipswich coal measures seems at first sight an exception to the general rule that volcanic action has usually followed close upon the heels of heavy sedimentation. The fact, however, must be borne in mind that it is more than probable that previous to the outbursts which produced the Brisbane tuff Permo-Carboniferous rocks were deposited to a considerable thickness along a shore line, perhaps somewhat east of the present shore line. In the Bowen River coalfield these sediments attain a thickness of several thousand feet, and in the Hunter River District of New South Wales are upwards of 10,000ft. thick. Stratigraphical evidence points strongly in this direction, so that the Brisbane tuffs were probably erupted subsequent to considerable sedimentation, though long before the downward movement of the earth's crust in that locality had ceased.

Probably upwards of 3,000ft. of Ipswich coal measures were then formed, and after some outbursts of lava, such as those represented at Ipswich, and possibly also those of Rosewood, the lower division of the Ipswich coal measures was slightly upheaved, and the Toowoomba basalts then flowed over an eroded and

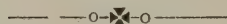
slightly inclined surface of these Mesozoic sediments. Subsequently the upper division of the Ipswich coal measures was deposited with slight unconformability on the Toowomba lavas, and further overflows of lava took place subsequent to or about the conclusion of the period of deposition of this upper division of the Ipswich

Members of the Association visiting Brisbane at the next annual meeting will, of course, have every facility for studying the highly interesting volcanic rocks at Brisbane and in its neighborhood, and further evidence may then be adduced to explain the apparently anomalous position of the Brisbane tuffs at the base of a great sedimentary series.



10.—THE SYSTEMATIC APPLICATION OF PHOTOGRAPHY AS AN AID IN MAKING GEOLOGICAL SURVEYS.

By E. P. BISHOP.



11.—THE SPECIFIC GRAVITIES OF SOME GEM STONES.

By A. LIVERSIDGE, M.A., F.R.S., Professor of Chemistry, University of Sydney.

The following table contains the specific gravities of some gem stones, which were all in the cut and polished condition, except in the cases specified. As the specimens were sufficiently free from flaws and mechanical impurities to be cut and polished for jewellery the specific gravities can be taken as those of pure minerals, and the results should be more satisfactory than those obtained from ordinary cabinet specimens, unless it can be shown that the specific gravity is altered by the pressure and other treatment they have received during the process of cutting and polishing.

The specific gravities were taken with special care on an Oertling's best chemical balance by direct weighing, *i.e.*, by suspending the specimen in a very small and light metal stirrup in distilled water. A specific gravity bottle was found, as is well

known, to give less accurate results. The temperature at the time of the determination is given in all cases and the results are corrected to 4° C., according to Rosetti's determinations of the density of water. The extremes of specific gravity, as given by F. W. Clarke in his "Constants of Nature," are added. The numerals refer to my catalogue of specimens, and are added in case of future reference;

TABLE OF SPECIFIC GRAVITIES.

No.	Name.	Locality.	Temperature.	Weight.	Specific Gravity.	Sp. Gr. Corrected to 4° C.
	BERYL (beryllium silico aluminate) —					
63	Beryl, pale green	—	20 C.	·1260	2·6359	2·6312
62	" " (5 small stones)	—	20 C.	·5640	2·7865	2·7816
43	" "	—	21·5 C.	·1225	2·7282	2·7228
39	" "	—	21·5 C.	1·0108	2·6826	2·6773
	(F. W. Clarke gives a range from 2·650 to 2·725)					
	CHRYSOBERYL (beryllium aluminate) —					
27	Cymophane or cat-eye (3 small stones)	Ceylon	19 C.	·3615	3·4330	3·4277
14	" "	"	21 C.	1·8065	3·7147	3·7074
15	" "	"	21 C.	2 1986	2·9299	2·9241
22	" "	"	19 C.	·5193	3·6882	3·6825
24	" " (4 small stones)	"	19 C.	·6445	3·7040	3·6982
	(F. W. Clarke gives a range from 3·597 to 3·860)					
	CHRYSOLEITE (magnesium, iron silicate) —					
45	Chrysolite	—	21·5 C.	·2186	3·3839	3·3772
	CORUNDUM (alumina) —					
33	Adamantine spar	N.S. Wales	21·5 C.	1·5550	3·9974	3·9895
	Ba. klyite (4 uncut stones)	"	18·5 C.	·5884	3·7382	3·7331
19	Ruby	Ceylon	21 C.	·3257	4·0160	4·0081
20	" "	"	21 C.	·2644	4·0060	3·9981
40	" " (6 small stones)	"	21·5 C.	·3590	3·9977	3·9·98
15	" " star	"	19 C.	·4230	3·8985	3·8925
13	" "	"	21 C.	·1876	4·0960	4·0880
10	" " red star	"	20 C.	3·7292	3·9920	3·9850
	(F. W. Clarke gives a range from 3·511 to 3·994)					
7	Sapphire, pale blue	N.S. Wales	19 C.	·3130	3·8882	3·8822
10	" " royal blue	"	18 C.	·1398	4·1117	4·1061
17	" "	"	19 C.	·6487	3 9404	3·9343
38	" "	"	21·5 C.	·2330	3·9829	3·9751
42	" "	"	21·5 C.	·4770	4 0219	4·0140
15	" " (4 specimens) dark colored	"	18·5 C.	·5650	4·1124	4·1068
5	" "	Ceylon	20 C.	2·5580	3·9323	3·9254
3	" " pale blue	"	19 C.	·8713	3·9730	3·9668
6	" "	"	20 C.	1·3654	3·9784	3·9714
7	" "	"	20 C.	1·2060	3·9476	3·9407
3	" "	"	20 C.	·8220	4·0039	3·99·9
1	" " yellow, large "Oriental topaz"	"	20 C.	5·0802	4·0089	4·0019
16	" "	"	19 C.	·5056	3·9164	3·9103

Table of Specific Gravities—continued.

No.	Name.	Locality.	Temperature.	Weight.	Specific Gravity.	Sp. Gr. Corrected to 4° C.
	CORUNDUM (alumina)—continued.					
2	Sapphire, star	Ceylon	19 C.	1.1352	3.9943	3.9981
9	" blue-grey star	"	20 C.	4.4812	3.9914	3.9844
11	"	"	21 C.	2.8314	3.9969	3.9890
12	"	"	21 C.	.2973	4.0284	4.0205
29	"	"	19 C.	1.2374	3.9967	3.9905
25	Oriental Emerald or green sapphire (2 small stones)	N.S. Wales	19 C.	.2872	4.1146	4.1082
23	" Emerald	"	19 C.	.9674	4.0041	3.9979
25	"	Cudjcong, N.S. Wales	18.5 C.	.5996	4.0733	4.0678
2	" yellow sapphire	Ceylon	20 C.	1.5972	3.9738	3.9668
3	" pale green	"	20 C.	2.9772	4.0000	3.9930
	(F. W. Clarke gives a range from 3.562 to 4.022)					
	DIAMOND—					
61	Diamond, dark, uncut, octohedron	Bingera, N.S. Wales	20 C.	.2920	3.4762	3.4701
	" (5 specimens) dark colored, uncut	—	18.5 C.	1.3220	3.5633	3.5585
	" (6 specimens) light colored, uncut	—	18.5 C.	2.2790	3.5278	3.5230
	(F. W. Clarke gives a range from 3.331 to 3.550)					
	FELDSPAR (potassium, aluminium silicate)—					
16	Moonstone	Ceylon	21 C.	.7370	2.5877	2.5826
17	"	"	21 C.	.3534	2.5833	2.5782
18	"	"	21 C.	.2288	2.5823	2.5772
	(F. W. Clarke gives a range from 2.570 to 2.595)					
	GARNETS—					
44	Garnet, almandine, iron aluminium silicate	—	21.5 C.	.1510	4.0266	4.0187
49a	" " (2 sp.)	—	21.5 C.	.1248	4.0519	4.0439
59	" " (3 sp.)	—	20 C.	1.3708	4.0058	3.9088
37	" " (2 sp.)	—	21.5 C.	.3038	4.1389	4.1308
41	" (2 very dark specimens).	—	21.5 C.	.2558	4.0862	4.0792
60	"	—	20 C.	1.3768	4.0637	4.0566
64	" (3 specimens) very dark.	—	20 C.	.3280	4.1000	4.0928
65	" (2 specimens) very dark.	—	20 C.	.2748	3.9458	3.9389
49	"	—	21.5 C.	.5714	4.2515	4.2431
53	" cinnamon stone, calcium, aluminium silicate	—	20 C.	.4566	3.6448	3.6384
28	" cinnamon stone	—	19 C.	.4039	3.6420	3.6363
54	" " less full of air bubbles	—	20 C.	.5157	3.7342	3.7276
	(F. W. Clarke gives a range "Almandine" from 3.90 to 4.236)					
	(F. W. Clarke gives a range "Cinnamon stone" from 3.522 to 3.609)					
50	LAPIS LAZULI (4 pieces) cut and polished for stud links	—	21.5 C.	1.3560	2.7684	2.7629
	PEARLS (calcium carbonate)—					
46	Pearl (3 specimens)	Ceylon	21.5 C.	.2841	2.7291.	2.7237
47	" " very irregular.	Torres Straits	21.5 C.	1.1422	2.6837	2.6784
48	" "	"	21.5 C.	.4510	2.6845.	2.6792

Table of Specific Gravities—continued.

No.	Name.	Locality.	Temperature.	Weight.	Specific Gravity.	Sp. Gr. Corrected to 4° C.
56	QUARTZ (silica)— Rock crystal..... (F. W. Clarke gives a range from 2·61 to 2·6507)	Torres Straits	20 C.	·2255	2·6877	2·6830
57	Amethyst..... (F. W. Clarke gives a range from 2·659 to 2·744)	— Oberstein	20 C. 18 C.	·4756 5·2408	2·6481 2·6565	2·6434 2·6529
26	Rose quartz (2 specimens)..... (F. W. Clarke gives a range from 2·651 to 2·6·8)	Ceylon	19 C.	1·1598	2·6674	2·6632
	Cairngorm.....	Oberstein	18 C.	22·4670	2·6555	2·6519
	“.....	“	18 C.	15·6290	2·6553	2·6517
	“.....	“	18 C.	13·3554	2·6567	2·6531
	“ brown.....	“	18 C.	3·9084	2·6567	2·6531
	(F. W. Clarke gives a range from 2·651 to 2·658, smoky)					
8	Fibrous quartz (“catseye”).....	Western District, N.S.W.	18·5 C.	1·2636	2·6703	2·6667
34	Opal hydrous silica (2 specimens)	N.S. Wales	19 C.	·1150	2·0105	2·0074
6	“ flawed.....	“	19 C.	·3616	2·0769	2·0746
	SPINEL (magnesium aluminate)—					
8	Spinel, dark blue.....	Ceylon	18 C.	·3306	3·6392	3·6343
35	“ puce.....	“	21·5 C.	·3468	3·5900	3·5829
36	“ dark puce..... (F. W. Clarke gives a range from 3·48 to 3·77)	“	21·5 C.	·1616	3·5831	3·5761
	TOPAZ (aluminium silico-fluoride)—					
	Topaz, colorless.....	N.S. Wales	19 C.	1·5213	3·5602	3·5547
1	“ “.....	“	18 C.	11·6010	3·5509	3·5461
18	“ “.....	“	20 C.	·6334	3·5110	3·5048
58	“ white (2 specimens).....	Ceylon	21·5 C.	2·0280	3·5717	3·5647
32	“ “.....	“	20 C.	·4282	3·5330	3·5268
51	“ yellow Brazilian.....	Brazil	21·5 C.	·3162	3·5728	3·5658
31	“ pink Brazilian, burnt.....	“	19 C.	1·0845	3·5406	3·5372
30	“ “.....	“	20 C.	·8920	3·5257	3·5195
52	“ Brazilian.....	“	19 C.	·4413	3·4676	3·4622
13	“ “.....	“	20 C.	·6585	3·5691	3·5628
55	(F. W. Clarke gives a range from 3·439 to 3·597)					
	TOURMALINE (aluminium borosilicate)—					
12	Tourmaline, brown..... (F. W. Clarke gives a range for brown Tourmaline from 3·035 to 3·068)	Ceylon	19 C.	·4835	3·0087	3·0040
	TURQUOISE, (hydrous aluminium phosphate)					
5	Turquoise..... (F. W. Clarke gives a range from 2·426 to 2·651)	Sinai	19 C.	3·4440	2·7388	2·7345
	ZIRCON (zirconium silicate)—					
4	Zircon, red.....	N.S. Wales	19 C.	·4026	4·4783	4·4714
9	“ “.....	“	18 C.	·3118	4·7822	4·7757
10	“ cut and polished.....	“	18·5 C.	1·8145	4·7191	4·7127
14	“ pale green..... (F. W. Clarke gives a range from 4·047 to 4·709 at 21° C.)	Ceylon	19 C.	·4160	4·5021	4·4951

12.—SCHEDULES FOR USE OF STUDENTS IN MINERALOGY.

By Professor LIVERSIDGE, M.A., F.R.S.

These are printed forms containing headings for all the principal properties of minerals, such as the system, crystallised and other forms, cleavage, fracture, hardness, &c., so that the work of the student is much facilitated, inasmuch as he has merely to fill up the blanks in the order in which he ascertains or verifies the characteristics of the minerals examined. The forms are printed on foolscap paper so as to afford sufficient space for the entries.

MINERALOGICAL SCHEDULE.

Student.....	Date.....
Name	
System.....	Forms.....
.....	
Cl .....	.....
Fr.....	H.....Sp. Gr.....
Str.....	Lu.....
Col .....	.....
Transp'y.....	.....
Comp.....	.....
B'pipe and reagents.....	.....
.....	
Assoc.....	.....
.....	
Occur.....	.....
.....	
Localities .....	.....
Uses.....	.....
.....	
Addit. remarks.....	.....

SCHEDULE FOR TESTING OF MINERALS.

In these printed forms blanks are left for the insertion of the results of the physical and chemical examination of unknown minerals, as shown below:—

SCHEDULE FOR THE TESTING OF MINERALS.

No.	Date	Collector
Locality		
Color		Lustre
Form		System
Cleavage		Fracture
Hardness	Streak	Touch Tongue
Magnetic	Electric	Effervesces with HCl
Before B'pipe in forceps.	Decrepitates	Deflagrates Volatilises Fusible
	Intumesces	Infusible Colors flame
"	on Pt. wire, with HCl or AgCl	livid blue = Cu or CuO. in Micro-cosmic salt bead, Blue color = Cl, green = I and blue-green = Br.
"	" with Na_2CO_3	Mineral Chameleon = Mn.
"	" with KNO_3 & Na_2CO_3 ,	yellow mass = Cr.
"	" $\text{KHSO}_4 + \text{CaF}_2$ =	green (B_2O_3)
"	on Charcoal or match = Metal	Brittle Malleable Magnetic
	Colored residue	Soluble in HCHNO_3 to Solution.
"	" gives incrustation	hot cold, and smell of
"	" " white residue, with Co_2NO_3 =	
"	" Na_2CO_3 & KCN = Metal	Brittle Malleable Magnetic
"	" " moistened on Silver,	brown color from Sulphates.
In Borax Bead Oxidising	Hot	Cold Enamel
" Reducing.		
Microcosmic Salt	Hot	Cold Enamel
Heat in open tube =	water, much, little, Alkaline, Acid.	Sublimate.
" " " Smell of	gas	Inflammable, reignites match
Ignited with Na or Mg in tube, add water =	PH_3 from Phosphates	
" " Na_2CO_3 & Charcoal =	mirror of Hg or As.	
Fuse with KHSO_4 in tube, glass corroded =	Fluorine	Violet fumes = I.
	Yellow = Br.	
Microscope =		
Spectroscope =		
Wt. in air =		Sp. Gr. =
Wt. in water =		
Soluble in H_2O , $\text{H}\bar{\text{A}}$, HCl, HNO_3 , Aq. Reg.		KHO, solution.
Solution contains Group 1, 2, 3, 4, 5, 6.		
Remarks:		
Examined by		

Section D.

BIOLOGY.

1.—ON THE FLORA OF THE LOWER GLENELG RIVER.

By J. P. ECKERT, F.R.H.S.

[ABSTRACT.]

The author offers a list of 350 flowering plants and ferns observed within the area embraced by Dartmoor, on the Glenelg River, MacDonnell Bay, and Discovery Bay, and prefaces the list by remarks on the geology and surface features of the country. Of the species which were determined by Baron F. von Müller the following have been traced into South Australia for the first time:—*Plagianthus pulchellus*, *Scleranthus visiflorus*, *Pimelia collina*, *Leptospermum flavescens*, *Coprosma Billardieri*, *Cynoglossum latifolium*, *Juncus Brownii*, *Phylloglossum Drummondii*.



2.—THE GEOGRAPHICAL DISTRIBUTION OF QUEENSLAND LICHENS.

By JOHN SHIRLEY, B.Sc., District Inspector of Schools, Queensland.

As far as at present ascertained, there are 735 species or marked varieties of lichens inhabiting Queensland; 485 of these are described in my "Lichen Flora of Queensland," published in 1889; and descriptions of the remainder have been given in the "Botany Bulletins" of the Agricultural Department of Queensland, published by the Government Printer. Many more species have yet to be discovered, but these will fall mainly among the Lecideas, Graphids, Pyrenulas, and other non-foliaceous kinds. The nobler and more showy lichens are now fairly well known. Although Queensland stretches across 18° of latitude, the climatic conditions do not vary as much as might be expected on account of the total absence of high mountains or mountain ranges, the Bellenden Ker Range, the highest in Queensland, rising to little

over 5,200 feet. The required conditions of shade and moisture are best found on the Pacific slope; and the scrubs of the lower flanks and tableland buttresses of the Main Range, and those of the rivers debouching from it, are the best collecting grounds for the lichenologist. The mountain scrubs contain by far the larger proportion of the frondose *Parmelias*, *Stictas*, *Physcias*, and their allies; while the river scrubs are richest in *Lecideas*, *Graphids*, *Thelotrema*s, *Pyrenulas*, and others, in which the thallus is reduced to a thin crust, or is hidden beneath the bark.

Comparing the known lichens of Queensland with those of Great Britain, it will be found that one-thirteenth of those inhabiting the British Islands have also been found in Queensland, but these belong mainly to *Cladoniæ* and *Parmeliæ*, and of the *Graphids* and *Gymnocarpous* species very few are common to the two countries. Similar remarks follow from a comparison of Queensland and Scandinavian lichens, but the plants common to both increase to one-twelfth, which is also the fraction of the Swiss lichens known to be inhabitants of our north-eastern colony.

Leaving Europe for Asia the species represented in Queensland becomes much more numerous; in a list of the lichens of Palestine and Egypt, the kinds possessed in common by Queensland and these Mediterranean countries form one-fourth of the whole; from Persia one-seventh; from the Andaman Islands, in the Bay of Bengal, one-fifth; and from Manipur, in India (a State lately notorious for the murder of British officers), the common kinds reached the high proportion of three-fifths. In the Rev. W. A. Leighton's paper on the lichens of Ceylon one-third of those named are also found in Queensland. Of Müller Aargau's "*Lichens of Tonquin*" one-half are plentifully distributed along our eastern coast; and of his "*Lichens of Japan*" we may also claim one-half as natives of our colony. As the general flora of the so-called Indian monsoon region and that peculiar to Australia overlap along the northern and eastern coasts of Queensland to a very large extent, and as many of the trees inhabiting the Queensland scrubs are natives of the islands intermediate between the Malay Peninsula and Australia, it is not remarkable that the lichens which to so large an extent find a home on the bark of these trees should agree in character and even in species. In Forbes' work, entitled "*A Naturalist's Visit to the Malay Archipelago*," of 856 plants reported, 241 are also to be found in the "*Synopsis of the Queensland Flora*."

Tasmania, New Caledonia, and New Zealand will naturally be expected to show many points of resemblance to Queensland in their respective lichen floras. Tasmania has Hunter Island and King Island as stepping-stones between Cape Grim and Cape Otway, and the Furneaux Islands as intermediate stages between Cape Portland and Wilson's Promontory; and three-fifths of its lichens are also found in Queensland. In New Zealand over one-

third of the lichens are common to it and Queensland; and in New Caledonia nearly one-half.

Taking Tuckerman's "North American Lichens" as our guide, one-seventh of the species reported from the northern half of the new world are included in the Queensland lists, showing a much closer affinity than in the case of European countries in the same latitude. But if we turn to South America the points of agreement become very remarkable when we consider the 8,000 miles of sea that intervene between Australia and the western coast of South America. In a list given by Nylander of the lichens of New Grenada rather less than one-third of the species are to be found in Queensland; and in Leighton's "Lichenes Andini et Amazonici" the species common to the opposite Pacific shores slightly exceed one-third. Krempelhuber's "Lichenes Argentinenses" show a similar ratio of agreement, while in lists by Müller Aargau of lichens from Paraguay and Brazil the number of species inhabiting Queensland and reported from each of the eastern countries of South America rises to over 50 per cent. of the whole.

For the remarkable coincidences between the lichen floras of Queensland and the South American continent I am unable to offer any sound explanation, as countries lying within similar distance of the equator in Asia, and having the same climatic conditions, rarely show an equal amount of agreement in the species of lichens contributed, although the phanerogamic floras are more extensively allied; yet it is worthy of note that Krempelhuber's study of lichens from the Sandwich Islands, and Jean Müller's determination of similar plants from the Society Islands, show that these groups, lying midway between Australia and America, have lichen floras with strong affinities to those of both neighboring continents. This remarkable similarity between the lichens of Queensland and those of the southern portion of South America gives additional weight to the gradually increasing belief that a land connection once existed between Australia and South America, and probably since Eocene times. New Zealand could have formed no part of the Antarctica of that day, but was rather an outlying and distant island off its coast. The evidence of the lichen floras of Paraguay and Brazil points rather to a connection with the southern end of South America than with any part of the coasts of Chili, Peru, or New Grenada.

Many lichens are wonderfully cosmopolitan in range, as the peculiar plant *Myriangium Duriei*, once regarded as a fungus, but now known to be a pyrenocarpous lichen; *Thamnolia vermicularis*, a lichen whose apothecia have yet to be discovered, and whose soft, pale, worm-like stems readily separate it from its allies. Other world-wide forms are *Parmelia perforata*, *P. perlata*, and *P. saxatilis*; the golden-crusted *Amphiloma murorum*; *Lecanora atra*, and *L. subfusca*; *Lecidea confuens*; *Buellia saxatilis* and *B. parasema*; and *Graphis scripta*. Not one pyrene-fruited

lichen is possessed in common by the British Islands and Queensland. The following are the authorities consulted:—

1. Queensland—Shirley's Lichen Flora of Queensland, and Botany Bulletins.

2. Great Britain—Leighton's Lichen Flora of Great Britain (3rd edition).

3. Scandinavia—Fries' Lichenographia Scandinavica, Upsal, 1871.

4. Switzerland—Stitzenberger's Lichenes Helvetici, 1882-3.

5. Germany—Rabenhorst's Deutschlands Kryptogamen-Flora, 1845.

6. Palestine and Egypt—Müller Aargau's Enumeratio Lichenum Ægyptiacorum et Lichenes Palæstinenses; Roume-guère's Revue Mycologique, Janvier, 1880.

7. Persia—Müller Aargau's Lichenes Persici, Hedwigia, 1892.

8. Andaman Islands—Nylander's Lichenes Insularum Andaman, 1874.

9. Manipur—Müller Aargau's Lichenes Manipurenses; Linnean Society's Journal, Botany, vol. xxix.

10. Tonquin—Müller Aargau's Lichenes Tonkinenses, Hedwigia, 1892.

11. Ceylon—Leighton's Lichens of Ceylon, Trans. Linn. Soc. xxvii., 161-185.

12. Japan—Müller Aargau's Lichenes Yatabeani; Nuovo Giornale Botanico Italiano, vol. xxiv.

13. New Caledonia—Nylander's Synopsis Lichenum Novæ Caledoniæ.

14. New Zealand—Hooker's Handbook of the Flora of New Zealand, part ii.; Knight's Contributions to the Lichenographia of New Zealand.

15. Tasmania—Shirley's List of the Known Lichens of Tasmania.

16. North America—Tuckerman's North American Lichens, parts i. and ii.

17. New Grenada—Nylander's Lichenographia Novo-Granatensis Prodomus.

18. Amazon and Andes—Leighton's Lichenes Amazonici et Andini; Trans. Linn. Soc. xxiii., pp. 433-460.

19. Argentine Republic—Krempelhuber's Lichenes Argentinenses.

20. Paraguay—Müller Aargau's Lichenes Paraguayenses; Revue Mycologique, Avril, 1888.

21. Brazil—Müller Aargau's Lichenes Schvenkiani, Hedwigia, 1891; Müller Aargau's Lichenes Catherinenses, Hedwigia, 1891.

22. Sandwich Islands—Krempelhuber's Flechten auf den Hawaiischen oder Sandwich-Inseln, gesammelt von Dr. Heinrich Wawra.

23. Society Islands—Müller Aargau's Lichenes Otaitenses a cl. G. Brunand lecti.

3.—BOTANICAL NOMENCLATURE WITH SPECIAL
REFERENCE TO THE FUNGI.

By D. McALPINE.

In compiling a systematic census of the Australian fungi, now being issued by the Department of Agriculture, Victoria, I found it necessary to set clearly before my mind the principle on which the naming was to be conducted. There is a good deal of confusion existing in this, as in other departments of botany, and I wished to avoid anything which would tend to make "confusion worse confounded." Accordingly the subject of botanical nomenclature with reference to the fungi was carefully thought out and a definite mode of naming adopted.

The first point considered was—What is the object in view in giving a special name to any plant? Generally speaking, it is to enable anyone conversant with the subject to readily recognise the particular plant intended by the author of the name. The name is not given to magnify the author of it nor for his convenience, but to serve the interests of the science. It is understood that the binomial system of nomenclature is strictly followed, that every plant has a generic and a specific name, the whole being considered as one, and the name of the author who first described it is appended—usually in an abbreviated form. Since the binomial system was first definitely adopted by Linnæus the authority for any name does not go beyond his time, and the one who first adopted any pre-Linnæan genus and used it with a specific name would be regarded as the author of that name.

It is comparatively easy to settle that every plant must have a generic and a specific name, but when several names have been given to the same plant by different authors, which one shall be chosen? To guide us here the most important principle or rule adopted by the congress of botanists, held at Paris in 1867, under the presidency of M. Alphonse de Candolle, was that of "priority of publication," meaning that a plant shall be known under the name first applied to it by its original describer, provided that the genus in which it was originally placed is still retained. This is a perfectly reasonable arrangement when qualified, as all rules must be, by common sense and the nature of the case. Thus names exist for the convenience of the science and not to gratify the whims of any individual, so that where the strict application of this law of priority of publication would upset well-established names and give no corresponding advantage—would merely, in fact, conform to the rule while creating confusion—then no change of name is necessary or desirable. The principle of "priority of publication" I have followed with the qualifications laid down.

The application of this principle is sometimes rendered difficult when the generic and specific name of a plant are considered independently. Each is only half a name and the part must not be

confounded with the whole. The proper name of a fungus is that which is correct (according to our knowledge) both in its generic and specific portion, and must be taken in its entirety. When the generic name is changed the specific name is transferred to the new genus, or, as the International Botanic Paris Congress directs, that when a species is transferred from one genus to another the specific name is maintained. But it sometimes happens, amid the mass of synonyms, that the generic and specific name of a species have both been changed, and the latest classifier has adopted a new genus without associating with it the very oldest specific name. In such a case, if the name has become established, it would be folly to disturb it for the mere purpose of giving it a flavor of antiquity. In the report of the Conifer Conference in 1891 Dr. Masters says:—" ' Priority ' has generally been respected, but when associated with inaccurate or inadequate publication, or when rigid adherence to it would be more likely to induce confusion than to facilitate research, to check rather than advance knowledge, then it has been disregarded or treated as obsolete." And Horace long before decided that " Use is lord and rightful arbiter of words," Why not of names?

So much for the names themselves, and now for the authority for the name. It is customary to append the name of the first describer to indicate exactly the particular species meant, as the same name has often been given to two distinct species by different authors. (It has occasionally happened that the same name has been given to the same fungus by two distinct authors, as in the case of " Native bread," Cooke and Massee having named and described it as *Polyporus Mylittæ* in " Grevillea " for December, 1892, and Professor Saccardo gave it the same name in " Hedwigia " for March, 1893.) But when the original describer has not correctly classified the species then the name of the correct classifier *replaces* that of the original describer. This seems a reasonable position to take up, although the nomenclature generally adopted in fungi is to give the name of the original describer in parentheses, followed by the name of the correct classifier. Professor Saccardo in his rules to phytographers in " Hedwigia " for January, 1891, distinctly states:—" The name of the original author of a species that has been removed to another genus should be given in parentheses as the author of the species, and outside the parentheses should be placed the name of the person who transferred the species to another genus." It is thus a question of relative merit, but botanical authorities are by no means agreed as to who should hold the first place—the original describer or the correct classifier. Thus, Sir Joseph Hooker says in his preface to " The Flora of British India " :—" The number of species described by authors who cannot determine their affinities increases annually, and I regard the naturalist who puts a described plant into its proper position, in regard to its alliance, is rendering a

greater service to science than its describer, when he either puts it into a wrong place or throws it into any of those chaotic heaps miscalled genera with which systematic works still abound." The practice recommended by Saccardo, and generally followed, seems to me to depart from the binomial system, and really to introduce a trinomial one, for there is involved in it the old generic name, as indicated by the author's name in parentheses, and the new one adopted. So I simply give the authority for the actual name adopted, introducing a slight modification to distinguish between the original describer and the correct classifier. The name of the former is always given in Roman characters, while that of the latter is in italics.

The necessity for appending authors' names at all has been questioned, and by no less an authority than the late Charles Darwin, as he considered that attaching for perpetuity the name of the first describer to species gave a direct premium to hasty work, to *naming* instead of *describing*. However, we must have names, and to indicate exactly the object to which the name was applied by the author thereof we require to give the authority for the name, at least for the present, in systematic works. As H. Strickland, M.A., F.R.S., wrote in reply to Darwin:—"The object of appending the name of a man to the name of a species is not to gratify the vanity of the man, but to indicate more precisely the species." But some attach more importance to an authority for a name than others. If it implies that the author of a name has contributed to our scientific knowledge of that particular species, as when he fixes a new genus for it, then the authority for the name is an important part of it. But if a name be regarded, as Dr. Masters regards it, as a mere label, in itself of no intrinsic consequence, then "in selecting a name that which is most generally used and most generally convenient should be retained." The diversity of naming is becoming so mixed that I believe it will ultimately come to this: that some standard list will be recognised, and the names distinguished by numbers rather than by authors' names.

At the present time there is a yearning on the part of botanists to have some better understanding as to the principles on which nomenclature should be based, so as to prevent or, at least, to stay the drift towards confusion. To bring about, if possible, a uniform system of nomenclature, and to prevent the multiplication of synonyms, a circular letter has been issued by a committee of Berlin botanists, including such well-known names as Professors Engler and Ascherson. They propose four resolutions, which refer only to the genera.

1. The starting point of the priority of the genera as well as the species is the year 1752 resp. 1753. The starting point of botanical nomenclature must be settled if there is to be uniformity in our naming, and the different dates suggested are the

following:—Kuntz favors 1735, being the year in which the first edition of the “*Systema Naturæ*” was published. Alphonse de Candolle suggested in the May number of the 1882 “*Journal of Botany*” 1737 as the date of the publication of the first edition of the “*Genera Plantarum*,” but before his lamented death on 4th April, 1893, he did not oppose 1753. The binomial system of botanical nomenclature was first consistently carried out in the first edition of the “*Species Plantarum*” published in 1753, and therefore this date forms a fitting starting point, as ably advocated by G. C. Druce, M.A.

2. *Nomina nuda* and *seminuda* are to be rejected. Pictures alone without diagnoses do not claim any priority of a genus. The necessity for a verbal diagnosis to distinguish genera is evident.

3. Similar names are to be conserved if they differ by ever so little in the last syllable; if they only differ in the mode of spelling the newer one must fall.

4. A fourth resolution recommended the retention of seventy-eight genera, which are large and universally known, although not allowable after the strictest rules of priority.

The first three resolutions have been generally approved of by the majority of botanists, among whom we need only mention here the veteran mycologist, Dr. M. C. Cooke, of London, and Professor Saccardo, of Italy, but the fourth resolution is likely to be withdrawn on account of the amount of opposition to it. Since the strict law of priority is so fiercely contended for by many eminent botanists, such as the late M. Alphonse de Candolle and others, we may give the reasons put forward in its favor by the Viennese botanists:—“They are led to oppose resolution 4, which would sanction a departure from the strict rule of priority, by the consideration that in presence of many botanists who assume a negative or aggressive position as regards the carrying out the principle of priority from considerations of convenience, or from not understanding the importance of a fixed nomenclature, it seems highly impolitic to admit the possibility of exceptions to the application of that principle. If the possibility of such exceptions is once allowed individuals will almost certainly consider themselves justified in increasing the number of the exceptions. On the other hand, such a list of genera is unnecessary for the reason that the number of necessary changes of name is considerably reduced by fixing the year 1753 as the beginning of nomenclature of genera. Again, the indication of a name, as generally customary, is much too variable in time and place to serve as the determining point in making out the proposed list and to inaugurate a permanent state of the nomenclature. Finally, one should not shrink from changing a name that has been in general use, but which has become untenable through the principle of priority, because it only requires the intelligent co-operation of all experts, especially of the compilers of text-books and descriptive botanical works, to make the new

names at once become current, at least with the younger men who take part in the building up of the science in the next few decades."

Where names have become almost consecrated by long use and yet do not conform to the principle of priority a way out of the difficulty would be to fix a period after which "use and wont" should have the force of law. A very good suggestion was thrown out by J. Shirley, B.Sc., in his presidential address before the Royal Society of Queensland on July 22nd, 1893, in which he said:—"The unearthing of fossil names to replace others which, though of later date, have at least the authority of years of acceptance may prove an operation of doubtful value. The replaced name, when ousted, probably has priority in a totally different order, and changes may thus be extended *ad infinitum*. It would be well to fix a certain term of years, general recognition during which would give fixity of title, as against obscure and forgotten names of greater age." I would suggest that when a name has reached its jubilee it ought to be allowed to retain its position unless something more weighty can be urged against its retention than a mere blind obedience to the principle of priority.

Having given a general idea of my views on the subject of botanical nomenclature, the way is now clear for an account of the plan pursued in the systematic census of Australian fungi.

1st. A consecutive number is given to each species for convenience of reference. Varieties have the number of their species with a distinguishing letter.

2nd. The number in Dr. Cooke's "Handbook of Australian Fungi" is next given for ready reference to the description of any species in that work.

3rd. The volume and number is next quoted for every species given in Saccardo's "Sylloge Fungorum," (10 vols.), this being a standard work on the fungi and the most complete and exhaustive at the present time. The references to Cooke and Saccardo will leave no doubt as to the species meant.

4th. The scientific name adopted for each species of fungus follows next. Saccardo is principally followed in the naming, but wherever more accurate names are given in recent monographs they are adopted. Capitals are only used for specific names when they are derived from persons (*Paxillus Muelleri*), genera (*Polyporus Mylittæ*), or appellatives where an old name is used specifically. The sub-genera of *Agaricus* are raised to the rank of genera.

5th. The authority for the name is next stated. The simple rule followed here is to give the actual author of the name adopted and not to make an author responsible for a name which is not his. The expedient has been adopted of indicating the name of the original describer by Roman characters, that is, of course, when the name given by him is retained, and the name of the correct

classifier in italics, when that of the original describer has been set aside on good scientific grounds. The literary reference also gives, as a rule the work in which the name given was first used.

It is astonishing how many names are given in standard works, followed by authors' names and references which refer to a discarded form of the name, and it has entailed a vast amount of labor in testing the original references wherever possible.

6th. The English name follows. This is merely an attempt to give an English rendering to the specific name for everyday use in the form of an adjective, which is sometimes very difficult to coin.

7th. The *habitat* is next given, the various colonies in which the species has been found being recorded, and it has been thought advisable to add a British *habitat* when it occurs there.

8th. The occurrence follows, indicating where the different kinds of fungi may be looked for, and giving the scientific name of the hosts in the case of parasitic species for use in the host index.

9th. General characters conclude the whole, giving such superficial and easily-recognisable characters as may serve as a guide in the rough discrimination of many species.

It is hoped that this list may serve as a complete record of Australian fungi known up to date, and, as it is accompanied by a provisional host index and a list of works on the subject, it is believed that it will give all workers in this branch a new start and a fresh impetus. A large number of recorded fungi have been overlooked by Dr. Cooke in his indispensable "Handbook of Australian Fungi," which are incorporated, and I am receiving friendly and hearty aid from various workers in the different colonies.

As regards the general classification, I have mainly adopted that of Saccardo in his "Sylloge Fungorum," and generally followed by Dr. M. C. Cooke in his "Handbook." The sequence of the twelve groups under which Australian fungi may at present be placed is as follows :—

- | | |
|----------------------|-------------------|
| I. Hymenomycetes | } Basidiomycetes. |
| II. Gastromycetes | |
| III. Uredines. | |
| IV. Pyrenomycetes | } Ascomycetes. |
| V. Discomycetes | |
| VI. Tuberoides. | |
| VII. Hyphomycetes. | |
| VIII. Sphaeropsides. | |
| IX. Saccharomycetes. | |
| X. Ustilagines. | |
| XI. Phycomycetes. | |
| XII. Myxomycetes. | |

In Saccardo's rules to phytographers, already referred to, it is stated:—"All names of all groups of plants should be in the feminine gender—Hymenomyceteæ, not Hymenomycetes." Never-

theless, for my present purpose I have ventured to use the common form, and to be consistent throughout in using the same ending.

There is one other phase of botanical nomenclature which stands in need of reform, and may be noticed in conclusion. I refer to the wanton way in which specific names are given in honor of individuals, often suggestive of being what botanists vulgarly call "sops." Such a system may sometimes advance science by encouraging the honored ones to persevere, but in the true interests of science I consider that it ought to be discouraged. If a new form is worthy of a distinctive name, then surely there is something distinctive about it which can be expressed in the specific name. Smith's Polyporus gives no clue, but "livid," or "rusty," or "snow-like" Polyporus fixes a feature in the name. Speaking as a teacher and in the interests of learners, I would appeal to those who have the responsibility of naming new forms to give us such names as will linger in the memory and serve to recall some important feature of form, or habit, or use.



4.—SUMMARY OF THE BIOLOGICAL RESULTS OF THE ELDER EXPLORING EXPEDITION.

By Professor TATE, F.G.S.

(WITHDRAWN.)



5.—PHOTOMICROGRAPHY AS A MEANS OF ILLUS- TRATING NATURAL OBJECTS.

By W. B. POOLE.

(WITHDRAWN.)



6.—FURTHER NOTES ON THE LAND PLANARIANS OF TASMANIA AND SOUTH AUSTRALIA.

By ARTHUR DENDY, D.Sc., F.L.S.

The few remarks which I have to make on this occasion may be regarded as a sequel to my notes on the same subject communicated to the Hobart meeting of this Association.

Since that time I have had the opportunity of examining a considerable number of land planarians from Tasmania and South

Australia, collected by Professor Spencer, Mr. Alexander Morton, Mr. G. C. Officer, Mr. L. J. Balfour, and Mr. Thos. Steele. Some of these species are new to science and of exceptional interest, and they will be described by me in another place in detail.

The total number of species now known from Tasmania is thus brought up to nine, one of which is also represented by a very distinct variety. These species are as follows:—

1. *Geoplana Walhallaë*, Dendy (also found in Victoria, but rare in both colonies).

2. *Geoplana Tasmaniana*, Darwin.—This species has been obtained in large numbers, and is now re-identified for the first time since its original discovery by Darwin on the occasion of the memorable voyage of the *Beagle*. It was, I believe, the first land planarian ever described from Australasia.

3. *Geoplana Dianensis*, n. sp.—A very large and handsome new species, apparently with considerable anatomical peculiarities.

4. *Geoplana Lucasi*, Dendy.—A large species, also found in Victoria in elevated country in the north-east of the colony.

5. *Geoplana Mortoni*, n. sp.—A handsome and well-marked new species, though evidently related to the Victorian and South Australian *G. Fletcheri*. I have named this species after Mr. Alexander Morton, from whom I first received it.

6. *Geoplana munda*, Fletcher and Hamilton.—This pretty little species, so abundant in Victoria, has been brought to light in large numbers in Tasmania by the investigations of Professor Spencer.

7. *Geoplana Adæ*, Dendy.—A slight variety of this well-known Victorian species was recorded from Tasmania in my last paper on the subject. I have since received three specimens of another very distinct variety, for which I propose the name *Geoplana Adæ*, var. *fusca*. They were collected by Professor Spencer at Lake St. Clair.

8. *Geoplana variegata*, Fletcher and Hamilton.—An unmistakable specimen of this very beautiful species was also collected by Professor Spencer. It is remarkable that, although a common Queensland and New South Wales species, it has not yet been recorded from Victoria.

9. *Geoplana typhlops*, n. sp.—In my notes communicated to the Hobart meeting of this Association I described specimens of what I took to be uncommon Victorian *Geoplana alba*, which were obtained from Mount Wellington. I pointed out at the time, however, that I could find no eyes, and that I should much like to examine fresh material. I have now received living material of the same species from Mr. Balfour, and more spirit material from Mr. Morton and Professor Spencer, collected in various parts of Tasmania; and the eyes appear to be undoubtedly absent. This is a very remarkable fact, for the eyes are distinctly present, albeit small, in the Victorian *G. alba*, and also in specimens of *G. alba* which I have obtained from New Zealand. Why they should be absent in all the

Tasmanian specimens is a mystery, but, since such is the case, I propose to give the specific name *typhlops* to these remarkable blind Tasmanian planarians. No blind land planarians have hitherto been described from Australasia, but it is interesting to note that a blind species, *Geobia subterranea*, is said to occur in Brazil, living in the burrows of earthworms, upon which it feeds. I learn from Mr. Morton that *Geoplana typhlops* is also sometimes found underground, but I do not think that this is by any means a distinguishing character. Coming now to the South Australian land planarians, we find that the number of species known is absurdly small as compared with the eastern colonies, namely, *two*. These species are:—

- (1) *Geoplana quinquelineata*, Fletcher and Hamilton.—A species very common in Victoria, and now represented from South Australia by two small specimens collected by Mr. Thomas Steele, on the extreme summit of Mount Lofty.
- (2) *Geoplana Fletcheri*, Dendy.—This species, although first described from Victoria, appears to have its home in the Mount Lofty district. In May, 1892, my friend, Mr. Thos. Steele, found it in large numbers in a deep gully behind Mount Lofty and sent me thirty-nine specimens alive! In Victoria it is distinctly rare. Mr. Steele's specimens are particularly interesting as showing a beautiful series of transitional stages in color markings between the more typical *G. Fletcheri*, as first described, and the very beautiful and at first sight very distinct variety *Adelaideansis*, which I described in my previous notes. The locality where Mr. Steele obtained his specimens was a dépôt for firewood brought from the surrounding forest, which perhaps accounts in some measure for the extraordinary number of specimens met with in such a limited area.

In conclusion, I would like to mention that Professor von Graff, whose work I referred to at the last meeting of this Association, is still engaged upon his great monograph of the land planarians. He informs me that he is about to visit Ceylon and Java, where he will probably have magnificent opportunities for studying the animals in a state of nature, and that any material received up to the end of 1894 will be welcome. As previously pointed out, my method of working has been to describe the external characters in all our scientific publications and then to forward named specimens to Professor von Graff for minute anatomical investigation and comparison with species from other parts of the world.

This method I am still following, and I would recommend those Australian naturalists who are interested in this beautiful and remarkable group of worms to adopt the same plan. I shall myself always be glad to receive specimens, especially from

South and Western Australia, either alive (packed in damp moss in tin boxes) or in strong spirits of wine. In the latter case the colors of the living animal should be noted carefully, and only a few specimens should be put in each bottle.



7.—EGGS OF THE AUSTRALIAN BREEDERS OF THE *CHARADRIIDÆ*, OR PLOVERS, SANDPIPERS, &c.

By A. J. CAMPBELL, F.L.S.

At the Hobart meeting of the Science Association Colonel Legge's valuable contribution "On the Geographical Distribution of the Australian *Limicolæ*" or Charadriine birds aroused much interest.

It may now be opportune to give descriptions of the eggs of the species of that most fascinating family found breeding in Australia—home breeders they may be called, or, as Colonel Legge terms them, resident species and partial migrants.

There are eighteen descriptions of such birds' eggs furnished in this article, sixteen of which are described from examples in the author's own collection. Such matter (original or otherwise) as is likely to prove interesting is added, also any information bearing on the nidification of the species. These are, namely:—

ÆDICNEMUS GRALLARIUS.

SOUTHERN STONE-CURLEW.

Figure—Gould: Birds of Australia, fol., vol. vi., pl. 5.

Ramsay's Tab. List—*Ædicnemus grallarius*, Lath.

Previous Descriptions of Eggs—Gould: Birds of Australia (1848), also Handbook, vol. ii., p. 211 (1865). Harting: Proc. Zool. Soc., p. 458 (1874). Ramsay: Proc. Zool. Soc., p. 335 (1877). North: Cat. Nests and Eggs, Australian Birds, with fig., p. 297 (1889).

Geographical Distribution—Whole of Australia.

Nest—Eggs are deposited on the bare ground. Mr. Hermann Lau, an excellent observer, once found them placed in the centre of an old cow dropping, at another time in a furrow of a cart wheel.

Eggs—Clutch, invariably 2; elegant in shape and inclined to oval; shell, thin and somewhat fine in texture; ground color, pale stone or light buff, blotched all over, sometimes with large markings of umber and dull slate. In some sets the markings are smaller or finer in character. In a handsome pair taken on the Werribee Plains, Victoria, the umber coloring predominates

on one example, while on the other the dull slate has prominence. There is a perceptible difference in specimens from Western Australia, which are warmer in general tone of color, shorter in length, and decidedly rounder in shape. Dimensions in centimetres of examples from Eastern and Western Australia :—

Eastern Eggs.		Western Eggs.	
Clutch A (1) ..	5·87 x 4·01	Clutch A (1) ..	5·15 x 4·0
(2) ..	5·8 x 4·02	(2) ..	5·12 x 3·96
“ B (1) ..	5·86 x 3·84	“ B (1) ..	5·4 x 4·07
(2) ..	5·8 x 3·84	(2) ..	5·38 x 4·09
“ C (1) ..	6·13 x 4·0	“ C (1) ..	5·42 x 4·1
(2) ..	6·0 x 4·08	(2) ..	5·62 x 4·04

Observations—The southern stone-curlew is a well-known bird, being common to the whole of Australia. Whether in the tropical forests of Queensland or the vast woods of Gippsland or the drier tracts of the interior provinces and of Western Australia, every dweller of the bush is familiar with the weird melancholy calls of the bird at night. Mr. Henry Seebohm, in his great work, “The Geographical Distribution of the family *Charadriidæ*, or the Plovers, Sandpipers, Snipes, and their Allies,” has left very few stones unturned, but in renaming our bird as the Eastern Australian stone-curlew, and in quoting his able friend Mr. J. E. Harting for reference for this description of the egg, he overlooked the fact that Mr. Harting’s specimen was taken in Western Australia.

It has been remarked that the eggs of stone-curlews frequenting the plains north or west of the Dividing Ranges are smaller in size and have the markings more blurred or less defined than those on the coastal side. However, it will be observed by the dimensions given above that the eggs from Western Australia are decidedly smaller. When on my visit I heard there were two varieties of stone-curlews in the western territory—the larger being a dark bird and the smaller light colored. But what we hear is not evidence and the thing lacks confirmation. Yet there may be something to account for the smaller-sized eggs from the western parts, especially when we remember that Gould hinted at a second race of these birds in Australia.

During my brief sojourn in the Cardwell district, Northern Queensland, August, 1885, I was surprised to see large flocks, perhaps fifty or sixty birds, of stone-curlews camping in the open forest glades. Probably it is a habit, especially amongst younger birds, to congregate in winter before dispersing southward or elsewhere to breed.

Breeding months include August to December and probably January. Early in September I recollect picking up, near Lake Tragowel, Victoria, a pair of eggs, just chipped; by night the chickens were hatched, able to stand up and feed themselves.

The prevailing color of the young in down is a light grey, with a dark marking in the shape of an oval line extending from the head to near the end of the back, also dark lines extend from the wings towards the tail. The parent birds at times feign lameness or perform other scheming actions to attract intruders from the vicinity of their young. The young, if alarmed, hide themselves and lie quite motionless, with necks outstretched, rendering their discovery a matter of difficulty. A farmer friend of mine was always able to checkmate the stone-curlews by the aid of a sagacious cattle dog. During breeding season, if he noticed a bird running away in a suspicious manner, when he crossed the trail, he would send the dog back along the line and so pick up the eggs or young.

As the southern stone-curlew is the initial species in the fascinating family of the *Charadriidæ*, I should like to direct attention to the fact that where a pair of eggs is the usual complement laid by any species the egg possessing the sharper point (at the smaller end) is nearly in every case the longer egg. No doubt the difference in shape and length may be attributed to the sexual difference of the embryos, and that the more lengthened or the sharper-pointed egg is the male. If we refer to the dimensions of the six clutches of the stone-curlew eggs we will observe that the No. 1 eggs (which have the sharper ends) are the longer in every instance except the last. It will be further seen that this rule applies to other species as they come under our notice. With reference to the longer and sharper-pointed eggs, I may mention that a relative of mine experimented with a setting of domestic fowls' eggs, selecting the longest and most pointed examples, and all without exception hatched out male birds.

ESACUS (ÆDICNEMUS) MAGNIROSTRIS.

LONG-BILLED STONE-CURLEW.

Figure—Gould: Birds of Australia, fol., vol. VI., pl. 6.

Ramsay's Tab. List—*Esacus magnirostris*, Geoff.

Previous Descriptions of Eggs—Gould: Birds of Australia (1848); also Hbdk., vol. II., p. 214 (1865). Hume: Nests and Eggs, Indian Birds, vol. III., p. 334 (1875 and 1890).

Geographical Distribution—North-West Australia, Northern Territory, North Queensland, and New Guinea.

Nest—The bare ground merely, or a small depression in the sand, a little above high-water mark.

Eggs—By analogy, 2—Gould states the ground color is creamy-white, streaked and marked all over with dark olive-brown, some of the markings being large and bold, without assuming any regular form, and others mere blotches about $\frac{1}{8}$ in. in diameter, while many of the streaks are as fine as a hair, and are of a crooked or zigzag form; length, $2\frac{1}{2}$ in. (6.35cm.) by $1\frac{3}{4}$ in. (4.45cm.) broad.

Mr. Hume states the eggs are handsome, and are oval in shape, a good deal compressed towards one end. The shell is tolerably fine and smooth, but without gloss. The ground color is creamy-stone, boldly blotched, streaked, and spotted with blackish-brown, paling in some places to a yellowish or raw sienna-brown. Besides these primary markings, a few small, pale, inky-purple, subsurface-looking spots and clouds are thinly scattered everywhere about the egg. The blackish-brown markings are chiefly confined to the larger end; dimensions, 2·6in. x 1·75in.

Observations—Except for the more elaborate details of Mr. Hume, it will be seen that the two descriptions, with dimensions above given, almost agree. Gould was favored with a specimen of this fine bird's egg from Commander J. M. R. Ince, who obtained it in the Port Darwin district.

HÆMATOPUS LONGIROSTRIS.

WHITE-BREASTED OYSTER-CATCHER.

Figure—Gould: Birds of Australia, fol., vol. VI., pl. 7.

Ramsay's Tab. List—*Hæmatopus longirostris*, Vieill.

Previous Descriptions of Eggs—Gould: Birds of Australia (1848); also Hdbk., vol. II., p. 216 (1865). Potts: Trans. New Zealand Inst., vol. II., p. 69 (1870). Buller: Birds of New Zealand (1873); also vol. II., p. 17 (1888). North: Cat. Nest and Eggs Australian Birds, p. 299 (1889).

Geographical Distribution—Coast of whole of Australia and Tasmania and south portion of New Guinea.

Nest—Merely a slight circular depression in the sand or in dry river beds near the sea shore.

Eggs—Clutch, 2, but in rare cases 3; inclined to oval in shape; texture of shell, strong; ground color, pale stony-grey, moderately marked with well-defined roundish blotches of umber; some of the blotches are confluent, others have a smudged appearance; there are also a few obsolete bluish-grey markings under the surface of the shell. Dimensions in centimetres of clutches, namely:—

Clutch A	.....	5·77 x 4·09 (sharper pointed egg)	
		5·73 x 4·15	
“ B	.....	6·15 x 4·0	“
		5·9 x 4·0	
“ C	.....	6·15 x 3·94	“
		6·22 x 4·0	

A specimen from King Sound, North-West Australia, measures 5·75 x 4·0 cm.

Observations—This handsome oyster-catcher in its garb of black and white may be seen in almost any portion of the Australian and Tasmanian coast, but is more abundant on the southern coast and especially on the islands in Bass Straits. During the expedition of the Field Naturalists' Club of Victoria to King Island, the latter

half of November, 1887, we enjoyed ample opportunities of observing these interesting shore dwellers, which were breeding at intervals all around the island. The white-breasted or pied oyster-catcher was the commoner of the two species of "red-bills." Sometimes a pair of birds betrayed their nest by uttering the loud piping double note of alarm, which became more frequent and solicitous in tone as we approached the locality of their home. At other times we would observe a bird running away in a suspicious manner from a particular spot. Picking up in the loose sand its footprints and following the track back invariably led us to the nest, which was merely a slight circular hollow or depression on the summit of a small sand dune immediately above high-water mark. The eggs were difficult to detect on account of the similarity of the coloration of the eggs with the sand round about. Of ten or twelve nests we took, none contained more than a pair of eggs; therefore instances of three eggs in a nest must be rare. A family of fishermen, who were reared at Port Albert and had much experience in shore life, remember in only one instance seeing three eggs in a clutch. From Gould and Sir Walter Buller we infer three is the usual complement. However, Mr. A. J. North describes a set of three taken by Mr. John Ramsay at Cape Upstart, Queensland.

Mr. Seebohm states that oyster-catchers are not known to breed within the tropics on the mainland, but only on islands. But it appears we have an exception in the white-breasted oyster-catcher, for I have received eggs from King Sound (North-West Australia), nearly 600 miles within the tropics, and near the North-West Cape Mr. Tom Carter, a sound field naturalist, took on the 20th of July several clutches, and again on the 17th of September a single egg from the same locality.

Except one fully fledged we did not observe on King Island the young which Gould states are capable of running soon, and in case of danger secrete themselves in a crevice of rocks or behind a stone. However, the young in down are greyish-buff, with black spots on the back, and with a dark longitudinal stripe on each side above the wing.

The breeding months are from July to January, the early months applying to the tropical or sub-tropical coast localities.

Sir Walter Buller records the interesting fact that this oyster-catcher does not always breed contiguous to the sea shore, as instances are known of its nesting on sandy plains a couple of miles or more inland.

HÆMATOPUS UNICOLOR.

SOOTY OYSTER-CATCHER.

Figure—Gould: Birds of Australia, fol., vol. VI., pl. 8.

Ramsay's Tab. List—*Hæmatopus unicolor*, Wagl.

Previous Descriptions of Eggs—Gould: Birds of Australia (1848), also Hdbk., vol. II., p. 218 (1865). Buller: Birds of New

Zealand (1873), also vol. II., p. 19 (1888). Legge: Proc. Roy. Soc., Tasmania, p. 130 (1887). North: Cat. Nests and Eggs, Australian Birds (with fig.), p. 300 (1889).

Geographical Distribution—Coast of whole of Australia and Tasmania.

Nest—Usually a rocky ledge or hollow not far distant from high-water mark.

Eggs—Clutch, 2; oval in shape; texture of shell, firm; ground color, stony-grey, moderately marked with irregular-shaped blotches (large and small) of umber or dark-brown, also a few dull greyish splashes and marks appear beneath the shell's surface. Dimensions in centimetres of clutches, namely:—

Clutch A	6.87 x 4.4	(the sharper pointed egg)
	6.55 x 4.36	
“ B	6.73 x 4.37	“
	6.36 x 4.35	
“ C	6.91 x 4.42	“
	6.73 x 4.36	

The eggs are similar to the pied oyster-catcher's, but are larger in size, darker in the ground color, and the character of the markings as a rule are not so uniformly roundish in shape.

Observations—We also found the sooty or black oyster-catcher on King Island, Bass Straits, but, although not so numerous, it was equally interesting as the white-breasted species with which the sooty at times co-mingled. Indeed hybrids, the progeny of the two birds, have been known. This may be the case with *H. ophthalmicus* (Castelnau and Ramsay), from the Gulf of Carpentaria, which, however, Mr. Seebohm has relegated to the synonyme of the black species. Of the several nests found during the Field Naturalists' expedition in November, 1887, to the above-mentioned island, the eggs, which were all in a more or less advanced state of incubation, were somewhat darker in color and a size larger than those of the other species. The sooty variety seemed to select a more rocky situation for its nesting place. The eggs I retained for my collection I took from a ridge of rocks almost surrounded by water at high tide. The nest contained a few broken shells, bits of stone, and small pieces of seaweed. The eggs recall a historical shipwreck, for within sight of where they were taken was the scene of the deplorable loss of the *Cataraqui*, which occurred on the west coast of King Island in 1845, when no less than 399 souls perished. Breeding months probably the same as the white breasted oyster-catcher, from July to January, but, possibly not so early in the southern districts. Young in down like the parents, are of a uniform blackish-brown.

All the plover family, almost without exception, resort to tactics such as feigning lameness or a broken wing to entice intruders

from their nest. Some species are more demonstrative than others, but I think the greatest mimic of all is undoubtedly the sooty oyster-catcher, for, according to Sir Walter Buller, if its young be approached it will not only feign lameness, but roll and tumble on its back as if in the throes of mortal agony in order to attract attention whilst the downy chicks make good their escape by taking to rock pools, diving under the projecting ledges, and hiding themselves in the crevices till all danger be overpast.

LOBIVANELLUS LOBATUS.

WATTLED PLOVER.

Figure—Gould: Birds of Australia, fol., vol. VI., pl. 9.

Ramsay's Tab. List—*Lobivanellus lobatus*, Lath.

Previous Descriptions of Eggs—Ramsay: Ibis, vol. III., new ser., with fig. (1867). Harting: Proc. Zool. Soc., p. 458 (1874). Campbell: Southern Science Record (1883).

Geographical Distribution—Queensland, New South Wales, Victoria, South Australia, Tasmania, and intermediate islands.

Nest—Merely a hollow on a little knoll or grassy plot, usually surrounded by water near the margin of a swamp. The nesting hollow is sometimes bare; in other instances lined with a few grass stalks.

Eggs—Clutch, 3-5, but usually 4; always deposited with points turned inwards; elegant in shape, inclined to be or are pyriform; shell, of fine texture; ground color, rich warmish green, boldly blotched or splashed all over with olive of different shades; dimensions in centimetres—(1) 5.1 x 3.5, (2) 5.0 x 3.55; also of a set taken by Mr. Dudley Le Souëf in the mallee district—(1) 5.2 x 3.67, (2) 5.1 x 3.6, (3) 4.94 x 3.7.

Observations—While the smaller black-breasted plover affects the barest parts of plains this exceedingly showy bird loves localities of a swampy nature, and its disposition is much the shyer of the two species, yet when called upon to defend its eggs or young the wattled plover is bold and courageous, attacking crows and animals long before they reach the nest by making sudden swoops upon and fairly screaming at them. On occasions, like many others of the race, this plover mimics actions of distress for the express purpose of diverting attention from its nest or young. Mr. Lau, on the Queensland Downs, has watched sitting birds disturbed by the approach of cattle or sheep. The bird does not quit its charge, but furiously flaps its wings and compels the animals to turn aside. Dr. Ramsay says it will even fly in the face of an animal in order to produce the desired effect.

Breeding months from the end of August to January. According to the wet season in the various localities, there are probably two broods reared in a season.

LOBIVANELLUS MILES (PERSONATUS.)

MASKED PLOVER.

Figure—Gould; Birds of Australia, fol., vol. VI., pl. 10.

Ramsay's Tab. List—*Lobivanellus miles*, Bodd.

Previous Descriptions of Eggs :—Gould: Birds of Australia (1848), also Hdbk., vol. II., p. 221 (1865).

Geographical Distribution—North-West Australia, Northern Territory, and North Queensland.

Nest—A hollow in the bare ground at the edge of a flat adjoining a salt marsh.

Eggs—Clutch, 3 and probably 4; in shape, somewhat pointed at the smaller ends; ground color, of a dull olive-yellow, dashed all over with spots and markings of blackish-brown and dark olive-brown, particularly at the larger end; length $1\frac{5}{8}$ in. (4.13cm.) by a breadth of $1\frac{3}{16}$ in. (3.0cm.)

Observations—All our knowledge at present of the nidification of this elegant plover is from Gould's "Birds of Australia." That great author mentions the breeding season as August and September, but doubtless it extends a month or two later, and in habits represents its southern ally, the better known wattled plover. However, the eggs of the masked plover are much smaller than we would have expected to find, for the dimensions, according to Gould, are only about the size of the black-breasted plover's eggs.

SARCIOPHORUS PECTORALIS.

BLACK-BREASTED PLOVER.

Figure—Gould: Birds of Australia, fol., vol. VI., pl. 11.

Ramsay's Tab. List—*Sarciophorus pectoralis*, Cuv.

Previous Descriptions of Eggs—Gould: Birds of Australia (1848), also Handbook, vol. II., p. 223 (1865); Ramsay: Ibis, vol. III., new ser., with fig. (1867); Harting: Proc. Zool. Soc., p. 458 (1874).

Geographical Distribution—Queensland, New South Wales, Victoria, South and West Australia, and Tasmania.

Nest—An indentation in the ground or slight sandy hollow on plains.

Eggs—Clutch, 4; placed points inwards; pyriform in shape; texture of shell, fine and slightly lustrous; ground color, light olive-grey or olive-stone, marked all over with small blotches and irregular spots of brown. Dimensions in centimetres—(1) 4.67 x 3.24; (2) 4.5 x 3.24; two examples of a smaller set taken on Darling Downs are—(1) 4.32 x 3.17; (2) 4.3 x 3.1. The eggs of this beautiful species are readily distinguished from those of the wattled plover by their smaller size and finer (smaller) character of markings.

Observations—Two of our leading ornithologists persistently overlook Tasmania as a locality of this species as well as the

wattled plover. But, in including Tasmania in the geographical range for both these birds, I find I am in very good company, for Colonel Legge, in his recent treatise "On the Geographical Distribution of the Australian *Limicola*," states with regard to the black-breasted plover that "it is not uncommon in the midland districts of Tasmania," while of the wattled species he remarks that it "is an abundant species in many parts of Tasmania." One of my early reminiscences as a boy was of the black-breasted plover. About 1860, near Yaloke—in those days my grandfather James Pinkerton's property on the Werribee River—the birds were in flocks of hundreds, and I well remember the good old gentleman pointing out to me a nest under a low shelving rock on the plain, and the timid bird, at our approach, half rising with its back against the roof of the stone, exposed a beautiful clutch of thickly-spotted brownish eggs.

The black-breasted plover is an early breeder. Eggs have been taken in Riverina in May, in June in South Australia, and in July in Victoria. On the Darling Downs, Queensland, they usually commence to lay in September, where Mr. Lau thinks they breed twice a year. Therefore we may infer that the breeding months in general include May to December, but chiefly the last four months. Here again, like many of the family, laying depends on the wet season, but observers in the interior have remarked it requires less rain to make them lay than the wattled plover, which in years of drought does not lay at all.

The young in down of the black-breasted or plain plover, which can run almost as soon as hatched, are finely dappled with black and brown, except the back of the neck and under parts, which are light-colored. As soon as fledged the young with the old congregate sometimes in immense numbers.

Why are the eggs of the plover family always placed together with the points inwards? I have heard two reasons assigned. One is that the keel of the sitting bird would fit exactly into, say, a clutch of four pear-shaped eggs and rest upon the points of the eggs; thus the bird would be comfortably balanced with two on either side. The other reason is that on account of the nest on the ground being a circular hollow the smaller or tapering ends of the eggs must naturally fall or fit into the contracting centre of the circle.

EURYROMIAS AUSTRALIS.

AUSTRALIAN DOTTREL.

Figure—Gould: Birds of Australia, fol., vol. vi., pl. 15.

Ramsay's Tab. List—*Eudromias australis*, Gould.

Previous Descriptions of Eggs—Ramsay: P.L.S., N.S.W., vol. VII. (1882). North: Cat. Nests and Eggs, Australian Birds, with fig., app. (1890).

Geographical Distribution—New South Wales, Victoria, South and West Australia.

Nest—Merely a little hollow in a mound or elevated portion of ground.

Eggs—Clutch, 3; in shape, pyriform, being considerably pointed at the smaller end; shell, thin and of dull surface; ground color, rich deep stone or buff, marked with small roundish blotches of umber or dark-brown, which are distributed chiefly on the larger half of the egg. In one example of the clutch now under notice the markings are inclined to circle round the obtuse end. Dimensions in centimetres of a beautiful set from Western Australia are—(1) 3.75 x 2.67; (2) 3.78 x 2.73; (3) 3.82 x 2.7.

The Australian dottrel's eggs are readily distinguished from the rest of the *Charadriidæ* by their richness of color.

Observations—It is a noteworthy fact that the immortal Gould in describing as new this interesting bird in 1840 stated that probably many years would elapse before anything was known of the habits and economy of this interior species. Gould's surmises proved correct, for it was not until 1882, or forty-two years afterwards, that its eggs were first discovered in New South Wales by Mr. E. G. Vickery during a surveying trip near Wilcannia, and which were described by Dr. Ramsay, of the Australian Museum. The eggs in my cabinet are from the Murchison district, Western Australia (the latest recorded colony included in the geographical range of this species), and were collected by Mr. C. Cadden in the season 1886.

Mr. K. H. Bennett in communicating with Mr. North sent the following interesting information, which I here copy:—"April 26th, 1889.—Found to-day a nest of *Eudromias australis*, containing three eggs; this is unusually early, for hitherto I have never known this bird to breed before September or October. The eggs were placed on a small natural mound of earth some 4in. or 5in. in diameter and about the same height above the surrounding ground, and completely covered with small sticks some 2in. or 3in. in length. I disturbed the bird from the nest on which she was sitting, and, noticing only the sticks, at first thought that in consequence of the ground all being covered with water, to the depth of 2in. or 3in., the result of recent heavy rains, that the bird in this particular instance had departed from the usual custom and had constructed a kind of nest, and that she had not deposited her eggs; but on closer examination I found the eggs on the bare ground, and that the sticks had been placed carefully over them as a safeguard against the keen-eyed crow, as whenever the old bird should leave her nest without this covering, situated as they were, they would have been very conspicuous, as the little mound in which they were placed was the only dry spot for 50yds. or 60yds. around."

Mr. Bennett also found another nest of this species with two eggs on the 29th April, covered in a similar curious manner with small sticks, and another on the 3rd May with two eggs. In the

latter instance they were not covered, but were simply deposited on the loose earth on high dry ground. It would appear therefore that the Australian dottrel lays in September and October in spring or during April and May in autumn, probably according to the rain, for instance, after the manner of the black-breasted plover (*Sarciophorus pectoralis*).

ÆGIALITIS BICINCTA.

DOUBLE-BANDED DOTTREL.

Figure—Gould: Birds of Australia, fol., vol. vi., pl. 16.

Rumsey's Tab. List—*Ægialitis bicincta*, Jard. & Selb.

Previous Descriptions of Eggs—Potts: Trans. New Zealand Inst., vol. II., p. 67 (1870); Buller: Birds of New Zealand (1873), also vol. II., p. 4 (1888); Campbell: Southern Science Record (1888).

Geographical Distribution—Australia in general, Tasmania, and New Guinea.

Nest—Merely the usual little hollow on plains in the vicinity of the coast or in dry river beds.

Eggs—Clutch, 3; soft in appearance, with thin shell; ground color of a greenish tinge or light greenish-stone (but sometimes greyish-stone), spotted and fancifully streaked fairly over with sepia or black. In some specimens the markings form patches about the obtuse end. Dimensions—(1) 3.56 x 2.5 cm.; (2) 3.48 x 2.56 cm. The eggs are very similar to those of the hooded dottrel (*Æ. monacha*) in shape, size, and character of markings, with the exception of having the greenish tinged ground color instead of the pale stone.

Observations—Eggs of the double-banded dottrel have not yet been recorded from Australia or Tasmania. The bird disappears from the mainland in spring and, according to the opinion of Colonel Legge, probably breeds on some of the islands in Bass Straits, as the young birds found in Tasmania during the autumn most likely come from that locality. In reference to the migration observed by Gould at Georgetown on the 15th May, Colonel Legge proceeds to remark that is about the time the birds would be arriving on a southern migration from their breeding grounds. May the birds not have come from breeding grounds in New Zealand on partial migration to Tasmania and Australia?

The late Mr. T. H. Potts, F.L.S., from whom I received my specimens, when first describing the eggs of this very interesting species before the Wellington Philosophical Society in 1869, remarked that "Our banded dottrel is worthy of belonging to the family of the *Charadriidæ*, for it is one of the most restless and wariest of birds during the breeding season. On the approach of an intruder it flies round and round, uttering its note of warning;

then, alighting on some rising ground, it steadily keeps watch. During the time it remains on the lookout it indulges in a peculiar habit of jerking its head backwards and forwards, uttering its monotonous 'twit-twit' at intervals." It is an early breeder, as would appear from Mr. Potts' notes—"August 2nd, 1856, saw a nest with two eggs, Rakaia River; September 1st, 1855, saw a nest with three eggs, Rakaia River; October 14th, 1857, young birds quite strong."

The young in down resemble little brownish puffs, being of a bright sandy-yellow, mottled with dark-brown on the upper surface, changing to yellowish-white on the underparts. They run as soon as hatched, and with great swiftness when alarmed.

Of this species Sir Walter Buller remarks:—"In location of the nest itself there is very little attempt of concealment, the bird apparently trusting more for protection to the assimilation of coloring, but after the young are hatched out the old birds (and particularly the female) manifest considerable solicitude for the safety of their offspring, and feign lameness or a damaged wing for alluring intruders away, a device which very often succeeds. The young bird runs the moment it quits the shell, and is not slow to second its parent in the art of self-preservation. Its sandy coloring makes it almost indistinguishable when squatting on the ground, and it has the instinct to remain perfectly motionless the moment it hears the note of alarm, even allowing itself to be handled without betraying a sign of vitality."

ÆGIALITIS MONACHA.

HOODED DOTTREL.

Figure—Gould: Birds of Australia, fol., vol. VI., pl. 18.

Ramsay's Tab. List—*Ægialitis monacha*, Geoff.

Previous Descriptions of Eggs—Gould: Birds of Australia (1848); also Hdbk., vol. II., p. 231 (1865). Ramsay: P.L.S., N.S.W., vol. VII. (1882). North: Cat. Nests and Eggs, Australian Birds, with fig., p. 304 (1889).

Geographical Distribution—South Queensland, New South Wales, Victoria, South and West Australia, Tasmania, and intermediate islands.

Nest—A slight circular depression in the sand just above high-water mark, sometimes scantily lined with small broken stems and bladders of seaweed and dead polyzoa.

Eggs—Clutch, 2, but usually 3; pyriform inclined in shape; ground color, of a beautiful soft stony shade, marked over with numerous spots and small irregular-shaped markings and dashes of dark brown or sepia. One egg of a clutch taken on Phillip Island, Victoria, is distinctly paler in the ground color than the remaining two. Dimensions in centimetres—(1) 3.55×2.6 ; (2) 3.47×2.61 ;

(3) 3.57×2.58 . The eggs, excepting for their larger size, much resemble in character those of the more common red-capped dottrel (*Æ. ruficapilla*).

Observations—I well remember the last time we celebrated as a public holiday the anniversary of the Proclamation of the New Constitution of Victoria. It was on November 23rd, 1884. I was on my way with another field naturalist to the mutton-bird (*Puffinus*) "rookery" on Cape Willomai, Phillip Island. While rounding a little sheltered cove on that island we flushed a hooded dottrel from its nest on the shining sand. The nest contained the full complement—three eggs, beautiful and fresh.

During the visit of the Field Naturalists' Club to King Island (1887) we could not sufficiently admire the graceful movements of these elegant dottrels, as they merrily tripped over the sandy beaches. Gould informs us that the hooded dottrel lays two eggs, but twice during the expedition did we find three in a nest. The eggs are by no means readily discovered, being speckled like the sand whereon they are placed.

The breeding months are from September to January, the principal month being November.

ÆGIALITIS NIGRIFRONS.

BLACK-FRONTED DOTTREL.

Figure—Gould: Birds of Australia, fol. vi., pl. 20.

Ramsay's Tab. List—*Ægialitis nigrifrons*, Cuv.

Previous Descriptions of Eggs—Gould: Birds of Australia (1848); also Hbdk., vol. II., p. 233 (1865). Harting: Proc. Zool. Soc., p. 459, with fig. (1874). Ramsay: Proc. Zool. Soc., p. 336 (1877).

Geographical Distribution—Australia in general.

Nest—The usual slight hollow in a pebbly river bed, or on a sandy ridge near water.

Eggs—Clutch, 3; with the points placed inwards; pyriform in shape, with thin, fine texture of shell; ground color, of a beautiful light stone or yellowish-buff, very closely and curiously marked over almost the whole surface, with minute specs and short angular lines of umber running into or crossing each other—intermingled are a number of dull greyish markings. Under a magnifying glass such letters as an undefined Z or K and other hieroglyphics may be discovered among the umber-colored lines. Dimensions of a clutch in centimetres—(1) 2.92×2.17 ; (2) 2.93×2.06 ; (3) 2.76×2.13 .

Another type of specimens is lighter in general color and more of a spotted nature, with the angular markings smudged, while the obscure greyish markings are more blotchy. (1) 3.06×2.1 cm.; (2) 2.83×2.04 cm.

Observations.—As Gould observes, this beautiful and delicate little dottrel avoids the boisterous and exposed sea beaches, preferring to dwell on the serener margins of rivers and lagoons in the more genial climate of the interior. That great naturalist was the first to take its eggs, which he found deposited on the ground beside the Namoi River, New South Wales.

My earliest recollections of this tame little species was the finding of a clutch of eggs on the shores of the Albert Park Lagoon, near Melbourne, by a schoolfellow, about 1869.

In the MS. left for my perusal by my good friend, Hermann Lau, I find, with regard to *Ægialitis nigrifrons*, he says:—"It was a long time before I was enabled to find its breeding-place, because of its cunningness and the similarity of the eggs to the color of the ground. Even when I first found the shell at Waroo (Queensland), on account of its large size, I could not accept it as belonging to this dear little bird had I not discovered near at hand three helpless young in a small gravel hollow between about half a dozen larger pebbles. Nothing soft was inside the nesting hollow, save remnants from insect food. On another occasion, while proceeding along a wide pebbly ridge, with the creek on one side and an ana-branch on the other, I found, by mere chance, three eggs, and observed the bird not far off. Birds, eggs or young, and pebbles are all much alike in color. There are evidently two broods in the season, because I have noticed eggs and young in October and again in December."

ÆGIALITIS RUFICAPILLA.

RED-CAPPED DOTTREL.

Figure—Gould: Birds of Australia, fol., vol. VI., pl. 17.

Ramsay's Tab. List—*Ægialitis ruficapilla*, Temm.

Previous Descriptions of Eggs—Gould: Birds of Australia (1848), also Hdbk., vol. II., p. 236 (1865). Harting: Proc. Zool. Soc., p. 459, with fig. (1874). Ramsay: Proc. Zool. Soc., p. 337 (1877). North: Cat. Nests and Eggs Austr. Bds., with fig., p. 306 (1889).

Geological Distribution—Whole of Australia, Tasmania, and New Guinea.

Nest—Usually of slight depression in the sandy ridges of the sea beach, sometimes ornamented with pieces of dried herbage or seaweed or a few small shells in the centre.

Eggs—Clutch, 2; shape, pyriform; shell, soft in appearance and lustreless; ground color, pale stony grey or stone-color, marked with blotches, dots, and minute splashes of dark brown or sepia. In some clutches the markings are finer in character and distributed over the surface, while in other instances they are more

blotched or are confluent about the upper quarter of the egg. Dimensions in centimetres of various clutches, namely:—

Clutch A	3·36 x 2·28 (the sharper pointed egg)	
	3·22 x 2·2	
“ B	3·05 x 2·33	“
	2·96 x 2·3	
“ C	3·09 x 2·2	“
	3·04 x 2·25	
“ D	2·94 x 2·16	“
	3·05 x 2·23	

Observations—Like Mr. A. J. North, I had my introduction when a boy to this, the smallest of our dottrels, on the sandy tracks interspersed with low scrub that stretched in those days between Sandridge (now Port Melbourne) and St. Kilda, but by the wonderful march of civilisation the favorite breeding grounds of the birds have long since been supplanted by a thriving suburb, a railway station, and a military road.

Although this endearing little shore wanderer loves the fore-shore of inland brackish lakes and backwaters, we observed a few members in company with the hooded dottrel on the boisterous and exposed situations on King Island; but nowhere have I seen the red-capped dottrel more plentiful than on the great sweep of sandy beach in Géographe Bay, Western Australia, where the eggs in doublets may be picked up for the seeking. I was never fortunate enough to enjoy Mr. North's experience of picking up three eggs from the one nest of this species. Although strictly a coastal bird, instances are known of the eggs having been taken in the interior.

The breeding months, like the hooded dottrel, are from September to January, November being the principal month.

My remarks on the stone-curlew, with reference to the sharper-pointed egg being as a rule the longer of a pair, are again strikingly illustrated in the red-capped dottrel. In four clutches, selected at random and measured, it will be seen there is only one exception (clutch D) to the rule.

ERYTHROGONYS CINCTUS.

RED-KNEED DOTTEL.

Figure—Gould: Birds of Australia, fol., vol. VI., pl. 21.

Ramsay's Tab. List—*Erythronys cinctus*, Gld.

Previous Descriptions of Eggs—Ramsay: P.L.S., N.S.W., vol. VII. (1882). Campbell: Southern Science Record (1883).

Geographical Distribution—Northern Territory, Queensland, New South Wales, Victoria, South, West (probably), and North-West Australia.

Nest—Eggs generally deposited on the moist ground near the margin of a swamp or lagoon.

Eggs—Clutch, 4; inclined to pyriform in shape; of soft appearance; and texture of shell, thin; ground color, stone, marbled closely and in a decided manner almost over the whole surface with fine wavy hair-like markings and blotches of dark sepia or black. In some examples the fine hair-like markings predominate, which, running together and interlacing, form irregular-shaped blotches in places. In shape and size the eggs exactly resemble those of the black-fronted dottrel (*Ægialitis nigrifrons*). Dimensions—(1) 2.97 x 2.17 cm., (2) 2.92 x 2.3 cm.

Observations—The red-kneed dottrel is a rare bird, and a dweller of the interior, where it prefers muddy flats and the borders of lagoons to the shingly river beds. Gould could never discover its eggs, nor could his two intelligent natives aid him with any information on the subject. It was not until 1882 that Dr. Ramsay described the eggs, which were collected by Mr. K. H. Bennett, in the Lachlan district. Mr. Bennett says he found the eggs, in several instances, on the damp ground at the water's edge of lagoons, and smeared over with mud, as if the birds had been shifting them from place to place, or, perhaps, as Dr. Ramsay suggests, they were purposely smeared over to prevent the eggs being detected. The eggs in my own collection, which were taken the same season as Dr. Ramsay's, but near a Murray River swamp, were smeared in the manner indicated.

The breeding months, so far as recorded for this species, are October, November and December.

GLAREOLA GRALLARIA.

AUSTRALIAN PRATINCOLE.

Figure—Gould: Birds of Australia, fol., vol. vi., pl. 22.

Ramsay's Tab. List—*Glareola grallaria*, Temm.

Previous Descriptions of Eggs—Ramsay: P.L.S., N.S.W., vol. VII. (1882). Campbell: Southern Science Record (1883).

Geographical Distribution—Australia in general (probably).

Nest—Usually a bare spot where the earth or sand assimilates the coloration of the eggs.

Eggs—Clutch, 2-3. At first sight are not unlike those of the lighter colored type of the black-fronted dottrel (*Ægialitis nigrifrons*), with the exception of being proportionally larger, inclined to oval, and not so pyriform in shape. Ground color, usually yellowish-buff or stone-color, but sometimes of a deep stone shade, lightly marked almost all over with spots and splashes of umber, intermingled with patches of grey. Dimensions in centimetres—(1) 3.28 x 2.34; (2) 3.2 x 2.34; (3) 3.08 x 2.42.

Observations—Authors agree that this swallow-like plover is the most elegant of its genus. It may be deemed a rare bird, and is particularly an inhabitant of the red plains and sandhills of the interior provinces of the continent. The eggs in my collection

are from the Mitchell district, Central Queensland, and were found by a brother of our Tasmanian oologist, Mr. Geo. K. Hinsby. The specimens I described in 1883, which were from Mr. H. H. Pick's collection, were taken in the Darling district, New South Wales. However, Dr. Ramsay first described the species the previous year from Mr. E. G. Vickery's collection, who procured them near Wilcannia in September, 1880.

The breeding months, so far as we possess knowledge at present, are September and October.

RECURVIROSTRA NOVÆ-HOLLANDIÆ.

RED-NECKED AVOCET.

Figure—Gould: Birds of Australia, fol., vol. vi., pl. 27.

Ramsay's Tab. List—*Recurvirostra rubricollis*, Temm.

Previous Description of Eggs—Ramsay: P.L.S., N.S.W., vol. VII. (1882).

Geographical Distribution—Australia in general and Tasmania.

Nest—The bare ground, usually near water.

Eggs—Clutch, 4; pyriform in shape; shell, soft in appearance and lustreless; ground color, a shade of deep-stone, or stone-color, with an olive tinge, moderately marked over the surface with blotches and large spots, mostly roundish in form, of dark-brown; also some duller markings of a slaty character appear under the shell's surface. Dimensions in centimetres—(1) 5.0 x 3.41; (2) 4.95 x 3.41; (3) 4.9 x 3.44.

The avocet's and the banded and white-headed stilts' eggs are much alike, but the avocet's may be at once detected by their large size.

Observations—Along with stilts, avocets, during the season, are frequently exposed for sale in the Melbourne market, but it would appear their eggs are extremely rare in collections.

Mr. K. H. Bennett informed Dr. Ramsay that the breeding months embrace September and December, that is for New South Wales, and that he took the specimens which Dr. Ramsay described from among the herbage usually seen growing about the sheep tanks in the interior. The avocet sometimes breeds in large companies, as was the case when my examples of eggs were gathered at Ulonga, about thirty miles from Hay, Riverina, 1879. Mr. Bennett also found similar colonies breeding on the margin of a lake in the interior during the season 1887.

HIMANTOPUS PECTORALIS.

BANDED STILT.

Figure—Gould: Birds of Australia, fol., vol. vi., pl. 26.

Ramsay's Tab. List—*Cladorhynchus pectoralis*, Du Bus.

Previous Descriptions of Eggs—Ramsay: P.L.S., N.S.W., vol. VII. (1882); Campbell: Southern Science Record (1883).

Geographical Distribution—New South Wales, Victoria, South and West Australia, and Tasmania.

Nest—The bare ground, but sometimes there is a semblance of a nesting-place lined with a few portions of dry reeds or other herbage.

Eggs—Clutch, 4; in shape inclined to pyriform; shell, firm in texture; ground color, rich olive-stone, or yellowish-olive, marked with spots and heavy blotches of sepia, together with a few lighter smudges of umber, especially on or near the obtuse end. Dimensions of odd examples in centimetres—(1) 4.46 x 3.14; (2) 4.37 x 3.17; (3) 4.33 x 3.15; (4) 4.65 x 3.14.

Observations—From swampy acres full of beautiful aquatic plants contiguous to the Murray River I have flushed, in company with other waterfowl, the banded stilt, which can be detected amongst the whirr of wings and voices of the other birds by its puppy-like barking notes. As in the days of good Gilbert, I made the acquaintance of this fine stilt on Rottnest Island, Western Australia, where it is locally known as the "Rottnest snipe." There they wade gracefully in the shallows of the salt lake, which is evidently a favorite feeding ground because the birds resort thither annually. About the middle of November (the 18th was the precise day the season of my visit) they arrive in companies of tens or twenties in number, apparently coming from the far interior because none are observed on the adjacent mainland, and gradually increasing in numbers till thousands may be seen upon the face of the lake. They remain all summer, departing again about April. During the interval between April and November, no doubt, they breed in some secluded part in the interior. But occasionally, especially during wet seasons, the banded stilts may be found breeding in Riverina, as in the year when my young friend, Mr. Lindsay Clark, enriched my collection with the eggs of this species, which he procured from near Booligal, on the Lachlan, New South Wales, the wet season of 1879.

HIMANTOPUS LEUCOCEPHALUS.

WHITE-HEADED STILT.

Figure—Gould: Birds of Australia, vol., fol. VI., pl. 24.

Ramsay's Tab. List—*Himantopus leucocephalus*, Gld.

Previous Descriptions of Eggs—Ramsay: Proc. Zool. Soc., p. 600 (1867). Potts: Trans. New Zealand Inst., vol. II., p. 70 (1870). Buller: Birds of New Zealand (1873); also vol. II., p. 23 (1888). Harting: Proc. Zool. Soc., p. 459 (1874).

Geographical Distribution—Whole of Australia, Tasmania, and New Guinea.

Nest—A slight depression in the ground, about 5 in. across by 1 in. deep, and containing a few pieces of grass.

Eggs.—Clutch, 4; pyriform in shape, but broad for the length; soft in appearance and lustreless; ground color, olive-stone, or light olive, fairly marked with roundish blotches and spots of dark brown or sepia, interspersed with the usual quotient of dull greyish markings. Dimensions of a clutch in centimetres—(1) 4.28 x 3.09; (2) 4.27 x 3.14; (3) 4.22 x 3.12; (4) 4.2 x 3.1.

The marked differences between the banded and white-headed stilts' eggs are that the former are usually more heavily blotched, while the latter possess a more greenish ground-color.

Observations.—The eggs above described are from New Zealand (I am aware that Mr. Seebohm treats the white-headed stilts from that quarter as a sub-species, while Gould and Sir Walter Buller regard it as identical with the Australian bird), and were taken by Mr. J. C. McLean on the 2nd November, 1890, at Repongaere, Poverty Bay, from a nest placed on a small islet or mound of earth, 2ft. or 3ft. square, rising from a sheet of shallow water. There were two other nests on adjoining islets—one containing four incubated eggs, and the other one egg (uncompleted clutch). Ten or a dozen birds were about the locality.

With reference to the pied or white-headed stilt, Sir Walter Buller states:—"I have found it nesting both on the dry sands or shingle beds at the mouth of our tidal rivers, and in grass meadows, on our cultivated lands, near the sea shore. I have also met it breeding in small companies, but each well apart, on the dry river beds many miles from the sea. . . . It usually commences to breed in October, but I have found newly-hatched young as late as the first week of January."

In Dr. Ramsay's interesting remarks of this species we read that "in 1865 large flocks arrived in company with the straw-necked and white ibises, and took up their abode in the lagoons and swamps in the neighborhood of Grafton, on the Clarence River, where, on my visit to that district in September, 1866, all three species were still enjoying themselves. A few days previous to my arrival in Grafton a black in the employ of Mr. J. Macgillivray, and a very intelligent collector, discovered a nest of this species containing four eggs, which have been secured for our collection. The nest was a slight structure, consisting merely of a few short pieces of rushes and grass, placed in and around a depression at the foot of a clump of rushes growing near the water's edge of a lagoon." However, the dimensions ($1\frac{3}{4}$ in. - $1\frac{1}{2}$ in. x $1\frac{1}{4}$ in. - $1\frac{1}{2}$ in.) of the eggs furnished by Dr. Ramsay would appear abnormally small compared with the size of the bird, and are much smaller than those given by other authorities.

The young in down is of various shades of fulvous yellow, varied on the upper part with brown, and with a series of square black dots down the back, and a broad streak of the same color on each thigh (Buller).

RHYNCHÆA AUSTRALIS.

AUSTRALIAN PAINTED-SNIPE.

Figure—Gould: Birds of Australia, fol., vol. vi., pl. 41.

Ramsay's Tab. List—*Rhynchæa Australis*, Gld.

Previous Descriptions of Eggs—Ramsay: P.L.S., N.S.W., 2nd ser., vol. 1. (1886). North: Cat. Nests and Eggs Austr. Bds., with fig, p. 312 (1889).

Geographical Distribution—Australia in general.

Nests—A slight depression in the ground, lined with herbage, near the margin of water.

Eggs—Clutch, 4; inclined to oval in shape, and of striking appearance; ground color is a light yellowish-buff or stone, heavily marked all over with large patches of dark olive or sepia, almost black in instances. These patches, some of which would cover the area of a three-penny piece, assume fanciful figures, and are conjoined with lesser and streaky markings. Where the ground color is visible greyish markings appear under the surface of the shell. Dimensions in centimetres—(1) 3.62 x 2.62; (2) 3.5 x 2.7; (3) 3.47 x 2.6.

Observations—In the season of 1839, on the Upper Hunter, New South Wales. Gould, in dissecting a female, found an egg in the ovarium, nearly the full size and ready to receive its calcareous covering, which left no doubt in the great naturalist's mind that the birds were breeding in that district. My namesake (Mr. Charles E. Campbell) noticed a pair of painted snipe, with a young family, among the herbage bordering the Bullock Creek, Pyramid Hill, Victoria, during October or November, 1884. Mr. North, in describing a handsome set of eggs taken by Mr. K. H. Bennett, near the margin of a swamp at Ivanhoe, New South Wales, in October, states the nest was a depression in the ground, neatly lined with broad eucalypt leaves. Mr. George Masters, curator of the MacLeayan Museum, Sydney, showed me a very fine clutch in the collection of that institution, which Mr. North has since given dimensions, &c., of. Mr. Masters was the first to explode the erroneous idea that they were the eggs of the true snipe (*Gallinago*), as we had supposed similar eggs to be.

Breeding Months—September to December.



8.—VERNACULAR LIST OF BIRDS.

By Colonel LEGGE, F.L.S.

(This paper is withheld from publication at present as the whole question of preparing lists of vernacular names of birds has been referred to special committees.—See Extract from Minutes of Council, this volume, page xxii.)

9.—A PLEA FOR A RATIONAL POPULAR NOMENCLATURE FOR AUSTRALIAN PLANTS.

By MAURICE HOLTZE, F.L.S., F.R.G.S.

The following few lines are intended to draw the attention of the Association to the desirability of providing our native flora with vernacular names which would at the same time be adequately euphonious and not misleading. Whether vernacular names are desirable or not can hardly be a question. Man, from the earliest times, has called his beloved flowers by names of his own language, and even universal knowledge of botany will hardly change a buttercup to a *Ranunculus*. Granted, then, that local names are necessary here as in every other country, the question arises, What names should rationally be given to our Australian plants? First of all, aboriginal names of plants, if known, should be retained as much as possible. What could be more euphonious than such names as waratah, quandong, bunya, yarra, brigalow, kurrajong, &c. If settlers throughout the colonies would, in every case where they can, ascertain the native name of any plant, take the trouble to collect specimens, and mark them with the name or names so ascertained, many of our native plants could doubtless be supplied with native names. Good work has already been done by Maiden in Sydney, and Bailey in Brisbane, and others, but much more remains yet to be done. Many other plants would be rationally accommodated by names suggested by their properties; so, for instance, the name of glory pea for *Clanthus puniceus*, poison pea for *Swainsonia*, green bird flower for *Crotolaria Cunninghamii*, umbrella tree for *Brassia actinophylla*, nettle tree for *Laportea gigas*, flame tree for *Sterculia acerifolia*, &c., should be retained. At the same time every effort should be made to relinquish such English names as are misleading. So, for instance, take our *Banksia*, which, in consequence of the large amount of honey which the flowers contain, has unfortunately been named by the early settlers "honeysuckle," a name by which is widely known that slender climber, the *Lonicera*. Not long ago I saw, in an English publication, that plants grow in some parts of Australia so vigorously that the honeysuckles were known to attain the size of trees. Not a few of our native plants have been provided by our early settlers with the names of English plants to which they were thought to bear some resemblance. Most of these names are also objectionable, as being misleading, and in many cases it is hard to say where the likeness to their English namesakes comes in. For instance, what likeness bears an *Exocarpus* to a cherry, a *Dodonæa* to a hop, or a *Bursaria* to a box? Is not quandong a better name than native peach, and would it not be better to replace those objectionable names by native names, or, where such names cannot be found, to use the botanical names instead? So many Australian plants are already popularly known by their

botanical names only that this presents no great difficulty, particularly with such names as *Banksia*, *Hakea*, *Kennedya*, *Bursaria*, *Boronia*, *Grevillea*, and many others. Most objectionable, however, are such names as sheaoak, Leichhardt's pine, &c., when a *Casuarina* has no more likeness to an oak, nor a *Sarcocephalus* to a pine, than a toad to a fish.

Some difficulty might possibly be found in properly distinguishing the numerous species of our large genera, such as the eucalyptus or gumtree tribe. In different localities different species of this genus are known by the same vernacular name; thus we find that there are twelve white gums, ten blue gums, eight red gums, and four spotted gums, eight ironbarks and eight stringybarks, three mallees, four woolly butts, and four bloodwoods, while the peppermints number seven. It can thus be easily seen that it will not be easy to suppress those names in every case but one, and to replace them for all other species by other adequate names. United action only can do this, and, as I think that this would be a proper subject for the consideration of this Association, I venture to suggest that a standing committee be appointed to prepare a list of rational and euphonious names for our native flowering plants.



10.—THE FAUNAL REGIONS OF AUSTRALIA.

By C. HEDLEY, F.L.S.

The discrimination of the various provinces into which the Australian fauna and flora group themselves has been frequently attempted. To the earlier naturalists, from a study of scanty material and with little or no personal knowledge of the continent, four divisions of east and west, temperate and tropical, seemed natural and sufficient. Hooker's "Essay on the Australian Flora" paved the way for a better understanding of the relations which various localities bore to each other. Owing to fundamental errors of his interpretation of Australian geology, Wallace's treatment of the subject in "Island Life" is of but slight value. To the writer, the most successful arrangement of the various biological regions yet proposed is that sketched by Professor Tate, in his address to the first meeting of this Association. This author accepts two main biological divisions—the *Autochthonian*, developed in west Australia, and the *Euronotian*, seated in eastern Australia and Tasmania; a subsidiary division, less in value and derivable from both the above, is the *Eremian*, or desert fauna and flora.

Taking this disposition as the basis of my remarks, I would observe that eastern Australia contains two distinct biological

populations, where Professor Tate has located one—the *Euronotian*. This title, I propose, should be reserved for that fauna and flora characteristic of Tasmania, Victoria, and southern New South Wales; while the second and very distinct fauna and flora developed on the coasts of Queensland and northern New South Wales would best be described as Papuan. Indeed, so distinct is this latter, that a separation of Australian life into Papuan and non-Papuan seems to the writer to be the primary divisions into which fall the Australian fauna and flora.

The types encountered by a traveller in tropical Queensland, or rather in that narrow belt of tropical Queensland hemmed in between the Cordillera and the Pacific, all wear a foreign aspect. Among mammals may be instanced the cuscus and tree kangaroo; among reptiles, the crocodile, the *Rana* or true frog, and the tree snake; among birds, the cassowary and rifle birds; among butterflies, the *Ornithoptera*; among plants, the wild banana, orange and mangosteen, the rhododendron, the epiphytic orchids, and the palms; so that, in the heart of a great Queensland "scrub," a naturalist could scarcely answer, from his surroundings, whether he were in New Guinea or Australia. It may be supposed that late in the Tertiary epoch Torres Straits, now only a few fathoms deep, was upheaved, and that a stream of Papuan life poured into Australia across the bridge so made.

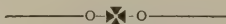
Sharply defined from the tropical jungle above mentioned are areas occupied by strictly Australian vegetation, which are left invariably in possession of the poorest tracts of land. From the rich lands, formerly no doubt possessed by them, everywhere have they been ousted by the invading flora.

Regarding the origin of the *Euronotian* fauna and flora, sundry facts collected by Mr. H. O. Forbes, in his paper on the Chatham Islands, would suggest a South American source. Assuming that, in or before the Miocene, continuous land extended from Tierra del Fuego to Tasmania, the derivation of the Australian marsupials appearing in the Pliocene from their South American allies *Prothylacinus* and *Amphiproviverra* of the Eocene would be clear. Mr. Forbes adduces strong confirmatory evidence from Professor Parker, who on embryological grounds does not hesitate to assume as ancestors of certain Australian crows a form allied to the American *Dendrocalaptine* birds. The distribution of the parrots and the cystignathous frogs appear also to sustain the theory. The extinct alligator, *Pallimnarchus*, found in Queensland and New South Wales, associated with *Diprotodon*, strengthens the chain of evidence, as does the occurrence in Tasmania and South Australia of *Gundlachia*, otherwise exclusively an American mollusk.

As the name implies, the *Autochthonian* is the oldest member of the Australian faunas and floras. The date of its arrival in Australia and the route which it traversed are lost in antiquity.

Seeing that many resemblances exist between our vegetation and that of Timor and the south-east Austro-Malayan islands, perhaps these lands afforded the passage to Australia.

Summary. — Superimposed one above another may be distinguished three divisions of Australian life. The earliest is the *Autochthonian*. Possibly this arrived from the Austro-Malayan islands in or before the Cretaceous era, and spread over the whole of Australia. The next is the *Euronotian*. Probably this reached Tasmania from South America not later than the Miocene epoch; many of the original inhabitants, particularly on the east coast, probably disappeared before the invaders. Thirdly, a contingent of Papuan forms seized on the Queensland coast late in the Tertiary, and likewise largely exterminated their predecessors.



11.—IMPORTANCE OF ASCERTAINING DISTRIBUTION OF AUSTRALIAN FAUNA.

By the Rev. THOS. BLACKBURN, B.A.

The subject that I have the honor to bring before the section for discussion to-day is, I venture to believe, second in importance to no subject whatever in natural history. It is the subject of the determination of the geographical distribution in Australia of the various natural objects that form the fauna of that region. What I am anxious to impress upon as many persons as possible is that it is a matter of urgent importance—that no weaker term will fitly characterise the need—to name and describe every item in the Australasian fauna, and place on permanent record the exact locality in which each species of the fauna is indigenous. I shall endeavor to establish the urgency of this matter on two independent grounds—on the ground of its importance as a contribution to science, and on the ground of its practical importance. To appreciate it as a factor in scientific knowledge it is necessary to place before the mind the ultimate aim of scientific work, which I take to be the discovery of the reason or reasons why everything in nature is as it is. This is a generalisation on which, I venture to think, we at present know nothing at all on scientific evidence. Innumerable instances will occur to the recollection of every student of science of facts in his own department of work which are to him *facts* and nothing more. I will illustrate this state of things from the small area in the field of investigation (small in relation to the whole—vast in relation to the possibilities of individual discovery), the small area in which I myself am working—viz., the *Coleoptera* of Australia. Now, the *Coleopterous* fauna of Australia, so far as we know, has distinctive characters as com-

pared with those of the rest of the world. I think I am right in saying, for example, that certain peculiarities in the structure of the *tarsi*—especially the absence of one or both of the *claws*—is more frequent in the *Coleoptera* of Australia than in those of any other region, so far as we know at present. And, again, the fauna of one *part* of Australia has distinctive characters as compared with that of other parts, so that a student fairly versed in the subject could say, with extreme probability of being right (if he were shown a collection of undescribed species), in what part of the continent it must have been obtained. Thus the *Erirehinini* are plentiful in southern Australia, but very rare in the northern regions; the *Anoplognathi* are plentiful in the east and rare in the west; the *Catasarci* are almost confined to the west, and so forth. But I do not think that, as yet, any *attempt* even has been made to *account for* such phenomena—to decide why the development, or the *creation*, of animal life has eventuated in one place in very different forms from those of another, or why in one spot one *type* or *family* should predominate, and in another another. And yet there must *be* a reason. On no biological theory that I have ever heard of is this kind of thing the result of mere accident—haphazard—chance. The investigation of such matters is, I take it, the scientific work of the future—perhaps of the distant future; there certainly seems to be nothing in it which it is not easy to believe is within the bounds of scientific possibilities. Now, a moment's reflection will show that for such an investigation ever to reach a satisfactory result the first necessity is "facts." Until we know with *absolute certainty* at least all the facts (relating to the fauna of a considerable number of land areas) which even now we perceive to be essential data, it will be waste of time to ask the question. Evidently it is futile to inquire "*Why* is this as it is?" until we *know* how it is. Well, then, let us think what the facts *are* that we need to know. Probably they include contributions from every branch of science; but I think the most obvious necessity (on the very threshold of the investigation) is an accurate catalogue of the species that are truly indigenous—*autochthonous*, to use a strictly accurate expression—in a considerable number of localities.

There is a considerable proportion of the earth's surface in which the construction of such a catalogue appears to be *impossible*. In Europe, for example, and indeed in all regions where any considerable civilisation has introduced commerce and travel, long before accurate scientific research was commenced, so many artificial influences have been at work that the fauna has become hopelessly complicated. Species have migrated; some have been removed from homes in which local influences have suppressed their indefinite reproduction to places where from various causes those influences have no longer operated, and their unchecked reproduction has enabled them to predominate to

the extent even of destroying what was genuinely *autochthonous*. It is a well-known fact that there are many species whose true natural *habitat* is unknown, and, so far as we can see, undiscoverable. The data were not placed on record at the period when their record would have been easy, and now the opportunity is gone.

Australia is probably, among the large portions of the earth's surface, that where nature has been least interfered with by artificial influences. A moment's consideration will show that on *a priori* grounds this *must* be the case, and it is unnecessary for me to waste your time by giving reasons for the assertion. Its being so is proved, moreover, by *experience*, for every student of geographical distribution is struck with the fact that there are very few species which have an extended range of occurrence in Australia as compared with those of other continents. This is not at all likely to be the result of anything inherently peculiar to Australia or its fauna, but simply of the fact that geographical distribution has not been tampered with here to any great extent by artificial means. Every year, however, this natural distribution of the Australian fauna is in an increasing ratio being disturbed. I may mention as an illustration that a large and handsome *Buprestid*, unquestionably *autochthonous* in Western Australia, has recently been brought to my notice as established in Victoria, doubtless having been introduced there through the importation of timber from Western Australia. On these grounds, therefore, I ask your assent to the proposition that it is a matter of incalculable importance to the future of scientific investigation that Australian biologists should make every possible effort to ascertain and place on record without any delay the facts of the geographical distribution of the Australian fauna, facts which in the course of even a few years may become if unrecorded irrevocably lost.

In arguing my case before a body of scientists such as I have the honor of now addressing I should be quite willing to rest it solely upon the scientific considerations that have so far formed the subject of my paper. But with persons not definitely interested in the discovery of science it is necessary in order to produce an effect to show that any suggested effort is likely to be fruitful in immediate practical results; and as the investigation of geographical distribution requires the co-operation of a far larger body of workers than can be furnished from the ranks of those already actively pursuing scientific studies, it is well that we should not overlook the bearing of this matter on practical affairs. I ask the attention, then, of the members of our Association to the fact that a knowledge of the geographical distribution of the Australian fauna is likely to be in the future one of the most important factors in determining the most efficacious methods of resisting the ravages of forms of life that are injurious to the interests of humanity on this continent.

One of the most interesting and remarkable aspects of the order of nature is that which presents it to us as a multitude of potentially destructive agencies so operating upon each other that the interests of each individual species are safeguarded by the ravages of the rest. We watch some beautiful butterfly fanning its wings to the sun on a summer's day, and we perhaps forget while we admire its glorious colors that if its species were able to increase and multiply to the full extent of its natural powers of reproduction for a few years it might possibly destroy the human race by depriving it of an essential article of food. Man's direct power of checking the natural increase of a butterfly is very small indeed. But there are other forms of life whose destructive powers are naturally exercised upon the butterfly, and it is owing to their operations that the butterfly is an object of admiration and not an instrument of ruin; and similarly throughout the whole economy of nature everything is in itself selfish and destructive, but the selfishness and destructiveness of each species is neutralised by the similar qualities of some *other* species, generally of *many* other species. Now it follows from this—from this beautiful balancing of the powers of the different forms of life—that when a species perishes the reason *may* be a very remote one, may be simply that something has occurred to remove (perhaps by an intricate chain of cause and effect) a check from interfering with the increase of something that is *destructive* to it. *Man's* powers are so out of proportion to the powers of all other living things that he seems likely on *a priori* grounds to habitually produce such a disturbance of the harmony of nature. For some reason or other he thinks it desirable to wage war on a plant or an animal and to greatly reduce its numbers. It is impossible to say what injury he may be inflicting on some of his interests that he has not regarded as concerned in the matter at all by diminishing some force in nature that it may be tends to keep in check some other force that is hostile to those particular interests.

Among all the means that man can employ for disturbing the order of nature there is perhaps none more likely to produce large results than that of introducing into the fauna of a particular region some species that is not indigenous to it. An introduced species is perhaps in its nature unfavorable to something that is already there, and so increases the difficulties of life to that of which it is an enemy. It is perhaps capable of increasing the possibilities of multiplication to some *indigenous* species, and so causes it to assume an importance in the economy of nature that it had not previously possessed. It is often probably due almost entirely to the *immigration* of species—very often deliberately caused by man—that some species become what we call *pests*; and where that is *not* the cause the cause is often to be found in the fact that man has thought fit to destroy something whose destruction has removed a check that had previously limited the

increase of what, in the absence of the destroyed influence, assumes unnatural prominence. It is well known that, in many places, introduced plants have destroyed—or, at any rate, seemed likely to destroy—certain indigenous plants, and that introduced *birds* have vastly increased the difficulties of the fruit producers; while it is not at all improbable that if the required mammalia were introduced into given regions they might absolutely *exterminate* numerous species of animals. Why so, if they do it not in their own home? I reply simply because in their own home they are a factor in nature's balance of power and no more. Nature has provided (I use the term "nature" not, of course, as indicating any particular view of first causes, but simply to avoid involving my argument in any reference to first causes with which it is not concerned)—*nature* has provided the necessary check upon the destructive tendencies of these things in the places where she has herself placed them. They exist *naturally* only where their environment requires them. If their environment is changed by *natural* means, ordinarily it will be by *gradual* means and the whole environment will change together in such fashion as to preserve the balance; but if *man* changes the environment, he will do it *suddenly*, and the balance is lost. Thus, if we take the instance of that family of small *Coleoptera*, the *Cucujidæ*, which is destroying vast quantities of valuable merchandise all over the world, or the family of scale insects so highly injurious to orange and other plantations of fruit trees, there can be little doubt that each species was comparatively harmless in the environment where it was *autochthonous* because it was preyed upon by other *autochthonous* species, which kept it in check. But if it is accidentally established in a new region it is extremely improbable that the accident which brought it there will also bring its antidote, and, if not, it becomes a scourge. Surely, then, the *scientific* method of reducing the ravages of what, unchecked, is injurious to any of man's interests is to modify its unnatural and unduly favorable new environments by introducing into those environments the particular influence that in its natural environments was hostile to its holding an excess of power beyond what nature intended it to wield; and I venture the opinion that in the future this method will find increasing favor in the eyes of all sensible practical men, and will become increasingly available and efficient. In order to apply this method it is, of course, necessary to study the *natural environment* of any introduced species, the undue multiplication of whose members it seems desirable to check. And in order to study the natural environment of any species it is necessary to know where it is *autochthonous*; and to know where it is *autochthonous* requires that there should be a record, in some place and form available to the student, of its occurrence. And in saying this I ask you to notice that, if it be so, I establish my second proposition, viz., that for practical reasons the investigation of the

geographical distribution of the Australian fauna is a matter of urgent and pressing importance.

Doubtless you are aware that some rough and preliminary indications have already been given of the results that may be expected from a scientific, and therefore sensible, mode of procedure in dealing with forms of life whose unnatural environments have rendered them dangerous to man's interests; and I need not weary you with details of the experiments that have been made in checking the ravages of the *Icerya* by the introduction of *Coccinellidae* to the districts infested by them, and of the wheat rust by the removal of the plants on which it passes the intermediate stage of its existence wherever those plants are less beneficial than the rust is injurious.

I do not hesitate to say that it would be, in the long run, a prudent investment on the part of any Government or combination of Governments to devote a large annual grant of money to organising and maintaining a department whose sole purpose should be the scientific investigation of these matters. If we consider the enormous losses that occur every year to the agriculturist through the ravages of organisms which have become injurious through their having been placed in an unnatural environment, we shall see at once that the value of a tithe of the amount so lost would richly provide for the expenses of the needed scientific investigation.

In conclusion, I may say that an eminent member of this Association has within the last few days mentioned to me a scheme that has occurred to his masterly intelligence which would, if carried out, be of the greatest value in promoting the studies I have been advocating; and I earnestly trust that he may be induced to take the matter up and deal with it successfully on such lines as he is meditating.



12.—VERNACULAR LIST OF BIRDS.

By A. J. CAMPBELL, F.L.S.

(This paper is withheld from publication for the present for the reason stated in connection with Col. Legge's paper, No. 8 of this section).

Section E.
GEOGRAPHY.

1.—NOTES ON THE PHYSIOGRAPHY OF SOUTH
GIPPSLAND.

By JAMES STIRLING.

INTRODUCTORY.

South Gippsland presents a charming field for physiographic research. It has been named the Eden of Victoria, and certainly is the most densely vegetated portion of south-east Australia. In previous papers on the Physiography of Gippsland, I have endeavored to present an outline of the leading physiographic features of the icy solitudes of the Australian Alps,* the *terra incognita* known as Croajingalong,† and the sub-alpine regions along the Tambo Valley.‡ In the present paper reference is made to the south-western portions of Gippsland, or, as it is better known, South Gippsland, which includes the most southerly region in Australia. The area is intersected by the 146th meridian, and lies between the 38th and 39th parallels of south latitude.

TOPOGRAPHY.

The Latrobe River Valley, which traverses the northern part of the area, and whose northern affluents find their source runnels among the snowy altitude of the south-western extension of the Australian Alps, as at Mount Baw Baw, separates the main dividing range from a mass of ranges known as the Strzelecki and Hoddle, whose spurs trend towards the coast-line, and after being depressed between Waratah Bay and Corner Inlet, rise to form the rocky-crested heights of Wilson's Promontory, the most southerly point in the Australian Continent, and which is apparently connected by a chain of islands in Bass Strait with Tasmania. The area to be described may be said to be bounded on the north by the Latrobe Valley; on the west by the watershed of the Tarago River and Koo-wee-rup Swamp, and Western Port Bay; on the south by the coast line from Cape Woolamai to Port Albert; and on the east by the plains bordering the Gippsland lakes. The principal streams draining the area are the southern tributaries of the Latrobe, as the Moe, Narracan, Morewell, Traralgon, and Flynn's Creek, which rise in the

* Trans., A.A.A.S., vol. i. pp. 359-385. † Trans., Geol. Soc. Australasia, vol. i.

‡ Trans., Roy. Soc. Victoria, vol. i., 1889, pp. 84-108.

Strzelecki Range; the Lang Lang and Bass, on the west, also draining the same range and entering Western Port Bay; the Powlett, on the south entering Bass Strait; the Tarwin entering Anderson's Inlet, and having, next to the Latrobe, the largest drainage area; and such minor streams as Stockyard Creek, Franklin and Agnes Rivers entering Corner Inlet; the Albert and Tara entering Port Albert harbor; and Merriman's Creek entering the Southern Ocean; the latter streams draining the Hoddle Range on the south-east and east.

If we follow first the main watershed line south of the Latrobe—known as the Strzelecki Range—along its course, then the Gippsland railway lines, and finally the coastline, a pretty clear idea will have been gained of the leading topographic and scenic features.

STRZELECKI RANGE

commences at the coastline at Griffith's Point, which forms the peninsula separating the waters of Western Port from Bass Straits, and also the passage to the former. A low undulating peninsula extends for several miles, with cliffs of from 50ft. to 150ft. on the seaward side, and gradually slopes towards Western Port on its northern side to Kilcunda. Here the spurs rise quickly to an elevation of 1,260ft. to the Blue Mountain Range, which forms the watershed line between the Powlett on the east and the Bass on the west; the slopes towards the Bass being steep, and those towards the Powlett more gradual. From the summit of the Bass Hill a grand view is obtained looking along the coast and to the north-west and north-east. Away to the west stretch the mangrove (*Avicennia tomentosa*) and titree (*Melaleuca ericifolia*) covering the Bass flats and estuary. In the middle distance rise French and Phillip Islands and, plainly discernible, two important historical headlands, viz.:—Settlement Point, where Bass landed in 1798, and Elizabeth Island, off Phillip Island, where Grant planted a garden in March, 1801; and away in dim outline rise the ranges between Western Port and Port Phillip. To the north-west the valley of the Bass is seen to rise in the dense forest-clad regions. Along the western slope of the Strzelecki Range is seen a low watershed line of heathy sandhills, separating it from the Lang Lang Valley; beyond that extends a long bleak stretch of dismal swamp land, known as the Koo-wee-rup, which seems to be lost in the distant haze, where its feeders, the Tarago and King Parrot Creek, and other streams enter it from the Gembrook Range. To the south rises Cape Woolamai, a bold granitic headland at the entrance to Western Port, forming an arrow-head-like extension of Phillip Island. Away to the west, to the extreme south of Phillip Island, stand out in bold relief the Pyramid Rock and Nebbies, where sportive fur seals (*Eutoria cinerea*) flapper up the rocks from out the crested waves. To the east and south-east the Powlett Valley has

cut its course along the margin of the Blue Mountain Range on the west, and drains a broad expanse of heathy undulating plains, which margin the coastline towards Cape Paterson and Waratah Bay.

From the Blue Mountain Range the watershed line proceeds north-easterly to the heads of the Bass and Powlett, presenting irregular contours, narrowing into an anticlinal ridge, expanding to a broad flat range, rising to rounded heights, depressed to low saddles, all covered with an almost impenetrable forest growth.

From the heads of the Powlett a minor watershed line radiates to the south-east, dividing it from the Tarwin River Valley, and on this the township of Korumburra, the centre of the Victorian black coal industry, is situated.

From this point, Bena, where the great southern railway crosses the watershed line, it trends northerly, and is known as McDonald's track; for a few miles it divides the waters flowing into the Tarwin on the east from the Bass on the west, until another minor watershed line trending westerly divides the Bass from the Lang Lang, on which the township of Powong is situated. From thence the main watershed line dividing the Tarwin and Lang Lang rises in successive gradients to South Warragul, overlooking the valley of the Latrobe; here a magnificent panorama is brought into view through the clearings on the settlers' holdings. This *point de vue* is 1,200ft. above sea level, and here the watershed line trends easterly, separating the streams flowing northerly into the Latrobe from those flowing southerly into the Tarwin. Away to the south-east there is an apparently endless vista of dense forest-clad ranges; to the west, long sloping sculptured ridges in the Lang Lang watershed tail off towards the Koo-wee-rup swamp and the waters of Western Port, which shimmer against the horizon. To the north, far across the deep valley of the Moe River, with long reaches of swamp amid the forest in the middle ground, rise long lines of spurs from the Great Dividing Range, which, becoming azure-tinted in the distance, culminate in the snow-flecked peaks of Mounts Baw Baw, Useful, and other high altitudes.

Looking at the contours it will be seen that the slopes towards the Moe from the Strzelecki Range are steep and regular, indicating an extensive fault scarp along which the Latrobe Valley was lowered during later Tertiary time. The northern slopes of the watershed line and several of the western watershed lines of tributary valleys, as the Narracan and Morewell, present similar fault scarps. Rising to an elevation of 1,500ft. at Allambee, the watershed line is depressed towards the heads of the Little Morewell river, at Mirboo, at 800ft. above sea level. It rises again towards Hoddle Range, and proceeds southerly, separating the Tarwin on the west from the Franklin on the east. Rising still higher it finds its culminating points in the Carrajung and Calignee Ranges at the heads of the Traralgon and Flynn's Creek, 2,100ft. above sea level.

From this locality a splendid view of the extensive lacustrine area of the Gippsland lakes is obtained to the east, and of the lower marshy reaches of the Latrobe, flanked in the distance by the high ridges proceeding from Mount Wellington; to the south and south-west are visible the long stretch of littoral country bordering the ninety-mile beach and the waters of Corner Inlet, with the bold granite peaks of Wilson's Promontory in the distance.

MAIN GIPPSLAND LINE.

The main railway from Melbourne to Bairnsdale traverses the Latrobe Valley. At Longwarrie the marshy flats bordering the Koo-wee-rup swamps give place, towards Drouin, to rising ground of rich volcanic soil; so also on the watershed line between the Tarago and King Parrot Creek on the west and the Moe on the east. From thence to Warragul similar rich volcanic soils and a dense vegetation are characteristic features. At Bloomfield the extensive flats of the Moe Valley are reached, and from this place past Darnum, Yarragon, Trafalgar, and Moe the high spurs of the Strzelecki Range run parallel with the railway line on the south. At Morewell the basin of the Morewell River causes a deflection of the range for some miles to the south, and similarly the basins of Traralgon and Flynn's Creek have deflected it south of Traralgon. It is within the belt of Tertiary flats extending from Darnum to Traralgon that the enormous beds of brown coal occur.

GREAT SOUTHERN RAILWAY.

Following this line of railway from the edge of the Koo-wee-rup Swamp, the following features are observed:—After passing through another stretch of swamp land, the line rises gradually through heathy sandhills to Nyora, at the edge of the forest region, and on the divide between the Lang Lang and Bass. From Nyora it descends to the Bass Valley at Loch, and then gradually rises through the Jeetho Valley (where the character of the forests are well seen in tall eucalyptus and dense undergrowth of arboreous shrubs and tall ferns, &c.), to Bena on the watershed line dividing the Bass and Powlett, and through Mesozoic ridges to Korumburra. It descends from this rising coal centre along the densely-timbered valley of Coalition Creek to Leongatha in the Tarwin Valley, where rich volcanic soils similar to those at Drouin and Warragul mask the Mesozoic strata. From Leongatha the line passes over a long stretch of heathy undulating plains covered with belts of gums across the Tarwin Valley to Fish Creek, on the Hoddle Range. Rising over the Hoddle Range, where forest ridges similar to those at Korumburra prevail, the line descends to the estuarine flats towards Foster Creek; again through heathy sandhills, with a magnificent

view of the Corner Inlet and Wilson's Promontory to the south. From Foster, Tertiary alluvial flats bordering Corner Inlet extend to Welshpool, with the Mesozoic hills in close proximity to the north, and trending north-east towards Yarram.

THE COASTLINE.

Following the coastline from Foster round Wilson's Promontory to Cape Woolamai the following features are observed:—Sand dunes occupy the intervening area between the low slopes of the Hoddle Range and the promontory, and between Corner Inlet and Waratah Bay. At the base of the promontory a small valley with fine alluvial flats separates the older sand dunes from the ridges which rise towards Mounts Boulder, Oberon, and others to an elevation of 2,500ft. On the eastern side Sealer's and Refuge Cove and Waterloo Bay form indentations between several rocky prominences, known as Cape Wellington, Brown's Head, &c. On the extreme south point the lighthouse is erected at an elevation of nearly 400ft. above sea level. On the western side Leonard, Norman, and Oberon bays indent the coastline; and from a point opposite the lighthouse, known as South-West Point, the coast curves to the east, north, and west to Cape Liptrap, forming Waratah Bay. Massive granite rocks cover the whole of the irregular mass of peaks and ridges which form the promontory. From the south point several islands extend into Bass Straits. From the entrance to the Darby River, on the eastern side, a continuous stretch of sand dunes prevails to beyond Shallow Inlet, where Silurian rocks, forming a low ridge from the Hoddle Range, occupy the strand, and are thence continuous to beyond Cape Liptrap. Beyond this the sand dunes again occur, and extend uninterruptedly to Anderson's Inlet and Cape Paterson. At Cape Paterson the Mesozoic rocks outcrop for several miles, with occasional cliffs and jutting bluffy headlands, not more than 100ft. in height. Another continuous sandy beach extends to the mouth of the Powlett, near Kilcunda, where the Mesozoic rocks again form a rocky strand, with a succession of cliffs to Griffith's Point.

GEOLOGICAL STRUCTURE.

PRE-SILURIAN OR CAMBRIAN.

At Waratah Bay the Upper Silurian conglomerates and limestones are seen to rest on distinctly bedded compact rocks of a felsitic character dipping to the north-west, while the overlying limestone beds dip to the south-east. From the lithological resemblance of these older rocks to Cambrian I am inclined to consider that we have here the remains of a formation which is conspicuously absent from Victoria, although well developed in South Australia.

UPPER SILURIAN.

Rocks of this age outcrop on the northern watershed of the Latrobe and on the coast from Cape Liptrap to Shallow Inlet, extending to Foster and Turton's Creek. Along the coast from Cape Liptrap to Waratah Bay the rocky strand is wholly occupied by these Upper Silurian sediments, intruded upon by aphanitic and diabasic dykes. The beds are greatly contorted, and consist of alternating dense shales, silicious sandstones, schistose grits, conglomerates, and limestones—the last converted into marbles, and showing splendid instances of the effects of contortion. The limestones near the quarries at Waratah Bay yield an abundance of corals, which are pronounced by Sir F. McCoy, F.R.S., to be new, and are now being examined by him for specific naming; several univalves and bivalves are also present, the latter including such widely distributed genera as *Atrypa spirigerina*, &c. The analysis of this limestone by Mr. Cosmo Newbery gave—carb. of lime, 94.90; silica, 2.25; iron, 2.85; magnesia, traces; water, 0.5. It is therefore a good stone for lime, and for such has been extensively quarried to supply the Melbourne market.

On the western shore of Corner Inlet, at a locality known as Yanakii, the Silurian rocks all rest on the granite of Wilson's Promontory. I have not noted any contact metamorphism, so that it is difficult to say if the former are laid down upon the latter or whether the granite is intrusive. Mr. Reginald Murray, however, inclines to the view that they may be so.* The curvature of the Silurian at Waratah Bay may be due to forces exerted during a period of Devonian plutonic activity.

GRANITE.

CAPE WOOLAMAI.

Cape Woolamai, which rises from Phillip Island to a height of over 300ft., is composed entirely of red granite. Microscopically it is a medium-grained granite composed of quartz, mica, and felspar, in which the pink or red felspar predominates. A slice prepared and examined by me gave the following petrographic characters:—

Quartz.—Mostly allotriomorphic. Inclosures consist of small flakes of biotite or of idiomorphic orthoclases and small cavities.

Felspar.—Most notable felspar is microperthite, an inter-laminated aggregate of orthoclase and plagioclase with the laminæ parallel to the orthopinacoid of orthoclase, appearing as fine stripes, on the two principal cleavage planes. Many of the orthoclase crystals show alteration to sericite. The plagioclase felspars are idiomorphic as to the orthoclase and exhibit polysynthetic twinning.

* Prog. Rep. and Geol. Sur., Victoria, p. 138, vol. 3.

Mica.—Principally well developed. Biotites as irregular plates with parallel striæ along the vertical axis; flakes of muscovite also occur.

Apatite.—Numerous hexagonal and spindle-shaped forms occur as inclusions in the biotites.

Zircon.—Bright pleochroic grains are seen along the margins of some of the biotites.

This granite is prized as an ornamental building stone. Its specific gravity is higher than any of the Victorian granites, and it takes a high polish. The grits and sandstones which form the western margin of the Mesozoic area at Griffith's Point are largely made up of the detritus of this granite. I have traced the altered biotites and feldspars through various stages and alterations from the normal state in which they occur in the granite to these clastic rocks. The mica has its laminae replaced by lenticular-shaped deposits of calcite, and the orthoclase feldspars are much kaolinised in the latter rocks. From its geological relations to the Silurian sediments to the north-west I refer this granite to the Devonian (Lower) Period.

WILSON'S PROMONTORY.

The whole of the promontory is made up of a very coarse grey granite; at one locality, however, it is pink and white. The prevailing structure is somewhat porphyritic, there being large irregular perthite and orthoclase crystals with subordinate mica, and amorphous quartz. Mr. Murray in his descriptions refers to its structure on the Corner Inlet coast as containing veins of feldspar, with enclosed quartz veins surrounding masses of fine granite, composed principally of quartz and feldspar with a little mica, and also as containing (in places) irregular veins of tourmaline with white mica, and nearly white granite containing very little mica. Near Yanakii it contains small garnets, zircons, green and blue sapphires, topaz, and small almandine rubies.

A slice prepared from the rock at Yanakii gave me the following:—

Quartz.—Allotriomorphic grains of quartz, in places containing swarms and streaks of fluid inclusions.

Feldspar.—Large perthites and orthoclase. Idiomorphic plagioclase feldspars occur within the areas occupied by the orthoclase or microperthite. In some of the glassy neutral-tinted feldspars cloudy or dusty aggregations of kaolinite are seen. There are also some beautiful fine sericite aggregations.

Mica.—Two kinds of mica occur. Biotites in lath-shaped sections, with frayed edges and iridescent flakes of muscovite, and also in basal sections with inclusions.

Tourmaline.—Small crystals occur as inclusions in the quartz.

Zircon.—Small crystals in the larger feldspars.

Apatite.—As inclusions in the biotites.

Garnets.—Numerous in portions of the slide near and in the biotites.

Ferrite.—Patches of ferrite occur.

OOLITIC.

The principal rocks underlying the mesozoic are Silurian, but towards Cape Woolamai they have been laid down on granite, and also near the contact of this granite and altered Silurian.

The basal members of the Mesozoic as observed at the Tyers River and Griffith's Point are massive conglomerates and agglomerates.

TYERS RIVER AND RENTOUL'S CREEK.

If we proceed down the Tyers River from the outcrop of Silurian limestone towards the Latrobe, the following sequence is observed :—Massive beds of conglomerates, consisting of hard silicious rocks, principally quartzite, indurated shale, and sandstone partly derived from the degradation of Silurian and partly of Devonian rocks. These conglomerates rest unconformably on the upraised edges of the Silurian, and contain lenticular-shaped deposits of an argillaceous shale, in which are found imprints of such characteristic oolitic plants as *Sphenopteris*, *Teniopteris*, *Alaethopteris*, &c. They are succeeded by thick beds of felspathic sandstone with subordinate beds of shale. At lower levels, both in the Tyers River and in Rentoul's Creek to the east, outcrops of carbonaceous shale and coal are seen.

KILCUNDA AND CAPE PATERSON.

At the south-west margin of the Mesozoic area at Griffith's Point a somewhat similar sequence is observed, but the basal members are made up of the detritus of granitic and metamorphic rocks, and form agglomerate bands, with lenticular deposits of shale, containing such vegetable imprints as *Teniopteris Carruthersii*, *T. Daintreii*, *Alaethopteris Australis*, *Sphenopteris Warraguliensis*, *Sagenopteris Carruthersii*, &c.

In following the coast along the cliffs towards Kilcunda the modes of occurrence and order of depositions of the beds are well seen. The felspathic sandstones are very distinctly current-bedded at Griffith's Point, where they begin to alternate with shales, and are full of drift carbonised or silicified wood. Towards "sandy waterholes" carbonaceous shales and attenuated thin seams of coal occur, which appear to merge at Kilcunda into one well-defined seam of coal 3ft. in thickness, now being worked. Borings carried on in the locality, and easterly towards the Powlett, disclosed the seam, and another at lower levels, as in No. 2 bore, which cut 2ft. 4in. at 460ft. from the surface, and 2ft. at 640ft. from the surface.

An average analysis of these coals gave:—Kilcunda—water, 5.91; vol. hydro-carbon, 29.60; fix. carb., 59.12; ash, 5.36.

Powlett—water, 7·60; vol. hydro-carbon, 28·22; fix. carb., 51·52; ash, 12·65.

At Cape Paterson the seams outcropping on the beach were—Rock vein, 2ft. 4in.; quartz veins, 4ft. 1in. Borings in the locality to the north-east disclosed one persistent seam of 2ft. 9in. in No. 2 bore. at depth of 115ft.; seam of 2ft. 10in. in No. 3 bore at depth of 116ft.; and in No. 7 bore cut 1ft. 5in. at 406ft., and 1ft. 3in. at 585ft. An average of analyses of this coal gave—water, 5·01; vol. hydro, 19·81; fix. carb., 47·35; ash, 28·8.

At Korumburra, in addition to the seam now being worked, of 4ft. in thickness, other seams were cut by boring in the vicinity as follows:—A 3ft. seam at 413ft.; 2ft. 6in. seam at 486ft.; 4ft. 11in. seam at 539ft.; 2ft. 6in. seam at 589ft. Average analysis of this coal gives—water, 5·40; vol. hydro, 29·80; fix. carb., 55·30; ash, 5·3. Outcrops occur in surrounding localities, as at Strzelecki, Silkstone, Korumburra, and Jeetho mines, and are being proved by boring.

At Jumbunna a seam exposed by outcrop in the creek averages 3ft. 6in.; bores put down to test its extension northerly cut the seam at No. 1 bore 374ft. of 4ft. 7in. in thickness, and at No. 2 bore, half a mile away, two seams, one of 3ft. 2in. at 1,054ft., and one of 2ft. 9in. at 1,256ft. Average analysis of the coal gave—water, 3·67; vol. hydro., 32·37; fix. carb., 60·17; ash, 5·66.

Outtrim.—An extension of this seam one mile to the west of the outcrop is 4ft. 7in. It has been traced for a mile still further to the west round the two hills in the Powlett Valley.

Berry's Creek.—In Tarwin Valley a seam 4ft. thick outcrops in Berry's Creek. Borings to the east disclose continuity of this and apparently other workable seams. In No. 4 bore a seam of 2ft. 4in. at 288ft., and another of 3ft. at 665ft. Analysis of this coal gave—water, 3·11; vol. hydro, 27·59; fix. carb., 59·55; ash, 9·75.

Coalville.—At Coalville a seam exposed by outcrop in Narracan Creek is being worked; it varies from 1ft. 6in. to 2ft. Average analysis of this coal gave—water, 7·09; vol. hydro., 26·23; fix. carb., 57·75; ash, 8·57.

Hazlewood.—Here a seam 2ft. 6in. thick outcrops in the gully. Borings in the locality to the east cut in No. 5 bore 2ft. 6in. coal at 194ft., 1ft. 7in. coal at 418ft., 1ft. 6in. coal at 1,600ft. Analysis gave—water, 12·15; vol. hydro., 20·85; fix. carb., 63·10; ash, 5·90.

This includes the principal workable seams at present discovered. A number of small seams of coal from 10in. to 1ft. 6in. occur all over the area, as in the heads of the Lang Lang tributaries of the Tarwin, Bass Valley, Foster, &c., but are not considered of workable thickness. The whole of the Mesozoic beds have been irregularly puckered up, and fault lines have been produced when the strata was relieved from the strain and tension of the pressure

which caused the uprisings. The lithological character of the beds has been described elsewhere.* It is somewhat remarkable that the sandstones are principally made up of partly volcanic materials, and may be derived from the detritus of Devonian ash beds and tufas, with an admixture of the felspathic constituents of Plutonic rocks.

Fossil Flora.—The vegetable fossils discovered during my surveys in South Gippsland have been referred to by Professor McCoy† as confirming the Oolitic age of the beds, as formerly suggested by him. He also remarks that the species of *Baiera* are closely allied to the French and German Oolitic species, and that *Albertia* and *Palissya* are represented by species not yet published in Australia.

The only representative of the fauna of the period yet discovered is *Unio Stirlingi*, which I have found at both the eastern and western portions of the area; and this, together with the flora, suggests fluviatile and lacustrine conditions as prevailing during the deposition of the Gippsland Oolitic beds. Although some of the members of the group are in parts calcareous, yet no distinct limestone bed has been proved in any part of the area.

EOCENE OR MIOCENE.

Overlying the Mesozoic rocks at various localities in the Latrobe, Tarwin, and Lang Lang valleys, and extending from Cape Liptrap to the Hoddle Ranges, are deposits of silicious conglomerates and quartzites with, in some localities, interbedded lenticular-shaped deposits of indurated clay, containing plant impressions of an Eocene facies, and apparently formed by fluviatile or lacustrine agencies. Associated with these silicious beds are deposits of gravels, sandy clays, clays, and lignites; the last apparently overlying the partly abraded surfaces of the more silicious rocks. Although occurring *in situ*, the contemporaneity of the lignite beds and the silicious conglomerates is by no means established. At Thorpdale,‡ at the heads of the Tarwin, the following section is obtained at 620ft. above sea level:—Older basalt, at lower levels; gravels (ferruginous), then a bed of lignite at 560ft., then 40ft. of brown coal resting upon clays at 480ft. above sea level, and underlying the clays about 80ft. of conglomerates resting on Mesozoic rocks.

At Calignee, on the north-eastern extension of the Strzelecki Range, are similar lignite beds, but at a much higher altitude; and similarly at Carrajung and McKerley's Creek, in the Neerim district.

In some localities the underlying strata have been silicified for a short distance from the contact with the conglomerates. This is

* Quarterly Reports of the Mining Department (see illustrations of diamond drill ores).

† Special report on Victorian coalfields, p. 12.

‡ See Quarterly Reports, Mines Dept., Victoria, for March, 1890, p. 31.

extremely probable, as we find in certain localities loose gravels which have been covered by basalt converted into ferruginous cemented gravels during the decomposition of the latter. A number of localities, where sections showing the relation of these silicious Tertiary drifts have been observed, have been described by Mr. Murray,* while I have observed similar beds at Frenchman's Gully, Neerim, Eaglehawk Creek, and other places along the northern watershed of the Latrobe, in the Narracan Creek and Little Morewell valleys, and on the Tara and Albert. In some localities the beds have evidently suffered erosion before the basaltic flows took place, and upon them, or in the hollows eroded through and upon them, younger auriferous gravels and the lignite beds were deposited. Thus it seems to me that instead of one contemporaneous deposit underlying the older basalts of South Gippsland, there are two; that if the basalt and the younger underlying gravels and lignite beds are Miocene, the silicious conglomerates are probably older, and may be either the equivalents of the marine oligoclase beds of Victoria or Older Eocene. I have nowhere observed a greater thickness than 200ft. of these sub-basaltic Tertiaries. In most cases they are considerably under 100ft., and in some instances are only a few feet in thickness. They occur from 300ft. to 800ft. above sea level along the flanks of the Strzelecki Range, and at Mirboo, and have been extensively lowered by faultings during later Tertiary times. The brown coal beds at Thorpdale, Calignee, and Carrajung contain a higher percentage of carbon than the larger and younger deposits at Morewell and other portions of the Latrobe. The following analyses have been made :—

	Water.	Vol. Hydro.	Fix. Carb.	Ash.
Thorpdale	14.50	31.87	46.30	6.36
Calignee	19.00	28.70	48.20	4.10
Carrajung	25.09	26.34	45.27	3.72
Or an average of	19.53	21.97	46.59	4.76

MIocene.

To the east of the Strzelecki Range, in the Merriman's Creek, between Merton and Stradbroke, are marine beds consisting of hard yellowish limestone, with soft intermediate layers, which are believed to be continuous with the Boggy Creek deposits near Sale, and which have been classed by Prof. McCoy as Miocene, from the assemblage of fossils examined by him. The relation of the

* Geological survey, South-western Gippsland, by R. A. T. Murray. Prog. Rept., Geol. Surv., Vict., vol. III., p. 148.

Merriman's Creek beds to the basaltic rocks of the Strzelecki and Hoddle Ranges has not yet been determined, but they are provisionally classed by Mr. Murray as of the same epoch.

OLDER VOLCANIC.

The silicious conglomerate, &c., and lignite beds just referred to are overlaid by basaltic rocks, which are fully 200ft. thick in some localities. They are very much decomposed over large areas, as between the Moe and Lang Lang and the latter and Tarwin tributaries, as at Drouen and Warragul, along the main Gippsland railway line, also surrounding Leongatha, on the Great Southern line. They cover the large extent of country from near Grantville, on Western Port Bay, along the Lower Bass Valley, to Griffith's Point, and constitute the principal formation on Phillip Island. On the latter, at Pyramid Point, there are evidences of two flows, with an intervening deposit of grit. In the Latrobe Valley, at Yarragon, borings have disclosed several flows. They cap the silicious conglomerate in the Neerim district, Tangil, and other affluents of the Latrobe to the east, and occur at various localities along the flanks, and in depressed areas on the watershed line of the Strzelecki Range, as in the heads of the Tarwin and Narracan creeks (Thorpdale), the valley of the Little Morewell, Mirboo, and at Calignee and Carrajung, at an altitude of 1,200ft. above sea level. At Yarragon and Boolara they have been lowered by faultings to a depth of nearly 900ft., and are, at these localities, covered by thick deposits of gravels, sandy clay, grits, and brown coal beds. There are no defined centres of eruption observable within the area, but the numerous dykes disturbing the Mesozoic strata, as at Korumburra, Bena, Powong, Tarwin River, and other localities, are evidently lines of eruption for the lava flows, whose continuity has been interrupted by subsequent enormous denudation and erosion, as well as faultings. In structure the basalts vary from compact to semi-crystalline, and partake frequently of the nature of olivine dolerites, in which the principal constituents are Labrador felspar, augite, and olivine, with much magnetite in some portions. Compact basalts have been described by Mr. A. W. Howitt* from the Narracan Creek and Morewell River.

The dykes examined by me at Korumburra, Bena, Jeetho Valley, Cruikston, near Powong, in the Tarwin Valley, near Kilcunda, near Trafalgar, and other localities, vary in texture from compact basalt, plagioclase basalt, and ophitic olivine dolerites to olivine gabbros. I have elsewhere described their petrographic characters.†

MIOCENE OR OLDER PLIOCENE.

In the Tangil River Valley are fluviatile deposits consisting of coarse gravels, clays, and sands cemented with ferruginous matter

* Prog. Rept. Geol. Sur., Vict., vol. III., p. 175. † Special report Victorian coalfields, p. 13.

and overlaid by basalt. In these have been found such fossil fruit as—*Spondylostrobus Smythii*, *Phymatocarpus Mackayi*, *Celyphina McCoyi*, *Conchotheca turgida*, and *Platycoila Sullivani*, upon which the deposits have been co-related with the Ballarat deep leads as Older Pliocene.* Evidences are wanting, however, to prove the precise age of the deposits; they may be contemporaneous with sub-basaltic auriferous gravels and their associated indurated clays, as on the Dargo High Plains,† where characteristic Miocene plant-remains have been found. The overlying basalt has been classed as newer volcanic, but, lithologically, it resembles the older basalts more than those of the western district of Victoria.

Boring in the Latrobe Valley at Yarragon has disclosed several distinct flows of basalt underlying that upon which the Pliocene brown coals of the Morewell district have been deposited, so that the Tangil basalt may be synchronous with one of these, and therefore of Miocene age.

OLDER PLIOCENE.

Above these basalts are extensive deposits, both fluviatile and marine, the latter consisting of sand rock, clays, and ferruginous sandstone, sometimes coarse enough to be called a conglomerate. This deposit extends along the Lower Tangil to the Latrobe, Shady Creek, and Moe Swamp; and apparently from Haunted Hill along the watershed line between the Morewell and Narracan Creek, thinning out over the older volcanic at an elevation of 900ft. above sea level. It also flanks the Strzelecki Range, along the southern Latrobe affluents round to Merriman's Creek and the Agnes River. It overlies the Miocene limestones of Merriman's Creek and covers elevations of 900ft. above sea level, as at Tom's Cap. In various parts of the Tarwin Valley it is found overlying the older volcanic, and similarly in the Bass Valley and over a considerable portion of Phillip and French Islands at Western Port.

MIDDLE PLIOCENE.

Under this division I am inclined to place the extensive brown coals of the Latrobe Valley and at Won Wren. The following section of the boring near Morewell will illustrate the sequence and phenomenal thickness of these lignitic deposits:—

	Ft.	In.
Surface and clay	36	5
Brown coal	29	8
Light drift and sandy clays	71	6
Brown coal	25	8
Carried forward	163	4

* Prog. Rep. Geol. Sur. Victoria, p. 152.

† Prog. Rep. Geol. Sur. Victoria.

Section of Bore near Morewell—continued.

	Ft.	In.
Brought forward	163	4
Dark woody clays.....	9	0
Brown coal	23	0
Brown coal, with slight layers of clay	26	4
Brown coal	227	10
Stiff clay	3	0
Brown coal	265	6
Light fireclay	4	6
Various clays.....	66	0
Solid brown coal	166	1
Sandy clay	5	9
White drift	5	0
Brown coal	43	8
Fine white drift	10	1
Total depth	1,019	1

These are probably the most extensive beds of brown coal in the world. The following analyses of lignites from the bore at Boolara are interesting, as showing the increase of carbon with the depth of the deposit:—

	Water.	Vol. Matter.	Fix. Carb.	Ash.
Eleven samples between 65ft. depth and surface	42·92	26·61	28·31	2·24
Thirteen samples between 65ft. and 125ft.	36·62	32·43	30·05	2·59
Eight samples between 125ft. and 162ft.	22·97	28·17	36·65	5·99
Or a mean result of	34·17	29·07	32·67	3·60

NEWER PLIOCENE AND PLEISTOCENE.

The whole of the extensive fluviatile deposits overlying the brown coals in the Latrobe Valley, Tarwin, and Lower Bass are classed as above. The driftal beds disclosed in boring at Traralgon belong to this series:—

	Ft.	In.
Sand	5	0
Clay	34	6
Drift and boulders	15	11
Rough gravel	0	9
Fine drift	13	0
Hard cemented sand and gravel	1	2
Heavy coarse drift	3	6
Fine and coarse drift intermixed with wood.....	28	2
	102	0

as do also the extensive sandy clays and associated gravels of the Koo-wee-rup Swamp, among which, at a depth of 6ft. from the surface, I have obtained several native tomahawks. On the slopes from Nyora to the Lang Lang the Pleistocene beds consist of whitish-grey and chrome-yellow to yellowish-brown sands. The older cemented sand dunes between the Darby River, Wilson's Promontory, and Yanakie are classed as Pleistocene. The two series so graduate into each other that at present any attempt to trace out their distribution would be misleading. They also shade off into the superficial soils both of degradation and transport which I have classed as Holocene.

CLIMATOLOGY.

There is, perhaps, no portion of South-East Australia where the relation between amount of rainfall and altitudinal range can be so well studied as in South Gippsland, or where the influence of the prevailing winds has had a marked effect in the erosion of the coastline over different geological formations.

At Griffith's Point, for instance, the prevailing winds are easterly in early spring and southerly during summer, the wind veering from north-west to south-west, with strongest gales from the latter.

If we compare the rainfall at stations to the west of the Strzelecki Range with that on the higher points of the range, and again with the low coastal regions on the east, the increase and decrease of rainfall corresponding to altitude is very marked:—1890.—San Remo (on the coast), 30·20 during 114 days, sea level; Grantville (on Western Port), 33·69 during 154 days, sea level; Powong (edge of Strzelecki Ranges), 48·93 during 89 days, 670ft.; Korumburra (centre of Strzelecki Ranges), 50·61 during 168 days, 760ft.; Geachville (heads of Tarwin), 52·99 during 143 days, 800ft.; Calignee (crest of Strzelecki Ranges), 60·00 during 170 days, 1,100ft.; Lisle Creek, 56·13 during 189 days, 500ft.; Foster (south-east coast, Corner Inlet), 49·55, 50ft.; Port Albert (coast, Corner Inlet), 28·97 during 92 days, sea level; Wilson's Promontory, 47·63 during 137 days, 800ft.

It will be noted that the rainfall is greater at the higher levels, and decreases to the east, owing to the precipitation over the former when carried over the area by the prevailing south-west and westerly winds. This increased rainfall has had a marked effect on the vegetation of the higher levels in that the most exuberant growths are found at the higher altitudes. An idea of the conditions of temperature, rainfall, and barometric pressures on the most southerly point in Australia will be gleaned from the data upon the following page, kindly supplied to me by our respected member, the talented Government Astronomer of Victoria, Mr. Ellery.

WILSON'S PROMONTORY.—METEOROLOGICAL DATA, 1892.

Month.	Mean Barometric Pressure.	Mean Temperature for the Month.	Maximum Temperature for the Month.	Minimum Temperature for the Month.	Total Rain-fall for the Month.	No. of Days of Rain.
	Inches.				Inches.	
January	29·566	60°·8	85°·0 on 19th	49°·0 on 14th	3·10	8
February	29·637	62°·6	85°·0 on 18th	53°·0 on 6th, 25th, 26th	0·03	1
March	29·619	62°·8	84°·0 on 25th	50°·0 on 27th	3·80	12
April	29·664	57°·5	79°·0 on 3rd	40°·0 on 12th	5·69	17
May	29·704	54°·6	69°·0 on 15th	44°·0 on 2nd	3·39	15
June	29·632	51°·2	60°·0 on 6th, 7th, 8th, 27th	38°·0 on 23rd	4·59	20
July	29·714	50°·2	61°·0 on 28th	36°·0 on 8th	5·01	17
August	29·564	51°·5	63°·0 on 26th	40°·0 on 4th	3·69	19
September	29·562	51°·5	65°·0 on 3rd	41°·0 on 16th	3·95	16
October	29·620	53°·5	68°·0 on 3rd	42°·0 on 25th	1·91	11
November	29·523	56°·9	65°·0 on 11th	44°·0 on 26th, 27th	2·66	10
December	29·451	56°·7	67°·0 on 24th	40°·9 on 9th	7·17	11
					44·99	157

THE VEGETATION OF SOUTH GIPPSLAND.

The more arboreous shrub vegetation of South Gippsland is common to eastern Victoria and the sub-alpine areas of the Australian Alps, and a large portion is identical with that flourishing in portion of the lowlands and less elevated mountains of Tasmania. We have even a New Zealand type in *Hedycara Cunninghami*, along with such exclusively continental species as *Howittia trilobularis*, *Panax sambucifolius*, *Sparganium angustifolium*, *Ottelia ovatifolia*, *Leptorrhynchus tenuifolius*, *Acacia pycnantha*, *Eucalyptus mocrorrhyncha*, *E. Leucoxydon*, *E. Mellidora*, *E. Gonicalyx*, *E. rostrata*, *Avicennia officinalis*, *Solanum armatum*, *S. pungentum*, *Myrsene variabilis*, which do not extend to Tasmania; there are also many conspicuous Tasmanian forms which do not occur in Victoria.



2.—THE FIRST CROSSING OF THE AUSTRALIAN CONTINENT BY J. McDOUALL STUART, WITH NOTES AND REMINISCENCES OF THE EXPLORATION.

By P. AULD.

3.—GEOGRAPHICAL NOMENCLATURE OF SOUTH AUSTRALIA.

By C. HOPE HARRIS.

PLATE XVI.

The main object of this paper is to account for the introduction of well-known European names into South Australia, and to narrate incidents, both of geographical and of historical interest, connected with them. Native names are also recorded, with their meanings, as far as possible; but lack of time at the disposal of the writer has necessarily limited the number of names dealt with. Some of the facts given are gathered from official sources; the remainder have been contributed by old residents, and authenticated by reference to documentary evidence contained in letters and diaries of early colonists; and it is hoped that this paper may be of sufficient interest to form part of a permanent record of events and circumstances which, though comparatively trivial in themselves, are of considerable importance in their relation to the geography of this province.

In accounting for the existence of a name, the question naturally occurs, Who has the right of naming? This, by general consent, is conceded to all discoverers and explorers, as regards places first visited by them or made known to the public through their agency. Strictly speaking, it is the prerogative of ownership, and in this sense is an assertion of personal claim; but the practice referred to is sanctioned by usage and recognised by compilers of maps under Government authority as a legitimate reward of enterprise; and, just as proprietorship carries with it the inalienable right of naming that which lawfully belongs to an individual, so royalty or its representatives, together with corporate bodies or duly constituted committees, have, by virtue of their representative character, similar privileges of conferring names to property under their control unnamed or unclaimed by others.

In the absence of public information, the appropriateness of names is not always evident, and not unfrequently is subjected to severe criticism. Upon this ground it seems desirable that a record should invariably be kept, not only of the bare fact of naming, but also of the reasons for the choice. This would have the advantage of preserving details connected with them which would be of ever-growing interest to posterity. Such a rule was almost invariably observed by the distinguished geographer, Matthew Flinders, and by inland explorers under Government direction; also in later years by leaders of similar expeditions under the patronage of public-spirited men and the auspices of the Royal Geographical Society. But from the difficulties which beset anyone engaged in a search among public records contained in official documents for details of early excursions from Adelaide into the surrounding country and other items of geographical interest, it is evident,

speaking generally, that no due sense has existed of the importance of preserving the kind of information contained in the latter part of this paper, here for the first time, I believe, set forth in a systematic manner. Nor can any hope of improvement be entertained with regard to a large class of names embracing hundreds and towns (concerning which it is not usual to record any reason for names given), unless the executive officers of the Government will accept a suggestion upon the matter. The rapidly extending list of towns and hundreds proclaimed by the Government calls urgently for some change in the manner or spirit of nomenclature. Many of the names on that list are names of persons and places unknown to the public here. It not unfrequently happens that persons who have made homes in various parts of the country are surprised and annoyed by the appearance of a strange appellation, officially notified as the designation of a new town or hundred, superseding the local name with which they have been long familiar. The Governors have probably not been made acquainted with these facts, for surely they would not disregard a respectful representation previously made of the claims of a traditional local name against one selected from a distant part of the globe or from their own household. Nominally, we all prefer native names; actually, we allow them to fade from memory, and replace them with our own evergreen patronymics, or with those belonging to members of Parliament.

Ignoring the wealth of history and romance that is wrapped up in the names given by the natives to various natural features and localities, we have obliterated them for the sake of names more dear to vice-regal representatives, such as Alice, Caroline, Anna, Joyce, Joanna, Julia, Laura, George, John, and James. Our territorial rights may be equivocal, but this surely does not trouble our conscience so much that we need hasten to destroy every vestige of the people who were once supreme here. We are said to be making history, but are we not lacking in courtesy in effacing the history of a less fortunate people whom we have displaced? We are not carrying into our colonial life the spirit of the instruction given by the Home Government to the South Australian Commissioners, nor following the best examples of older nations. The Romans had a good deal of experience in colonisation, and they were particular to preserve the names of places of the people they conquered. This was ordered upon the ground that names of places chronicle scenes, sights, actions, wisdom, folly, and fate, and are the people's heritage. Camden (A.D. 1586), quoting from Porphyry, a learned Athenian (A.D. 278), notes that barbarous names are emphatic and concise, and considers it the duty of an enlightened people to preserve them, as fixing ideas, images, or conceptions of preceding races. He believes that all native languages are significative; that is, they all have a meaning, and are not mere appellatives. What is here quoted appears to be equally

true of names which the Australian aborigines have applied to the distinctive features of their trackless home. We find their oldest words to be totemistic, that is, they have been derived from animals or objects of nature, associated with names of tribes. These totem names are useful in preserving distinctions of consanguinity, of great importance in their small communities. Other names refer to boundaries of tracts of country occupied by different tribes or sub-tribes. Some of the latter are descriptive of physical characteristics, some are of vague traditional import, some of them chronicle incidents of travel and war. Many refer to the presence of water, the existence of game, the haunts of reptiles, and the abode of insects. Probably they are all as full of that "child-like poetic fancy that occupies itself with the various aspects of nature, and expresses itself in gesticulations and rude art," as they are full of interest, mystery, and rhythmic music to European ears. Our lot it may never be to interpret the hidden meaning wrapped up in them, yet by their preservation we may hope to retain some shreds of knowledge, some fragments of ideas relating to the life history of a fast perishing people, whose existence is no fault of their own, and whose presence here is no blame, but whose extermination may perchance be counted shame to a civilisation that refuses to recognise them, and thus consigns them to the ignominy of oblivion. It surely is not necessary to close the annals of this inoffensive simple race; certainly it is not generous of us to destroy their only records, nor is it wise to exclude from mental view the panorama of their past.

The following extract from the *Government Gazette* of October 31st, 1839, is so highly commendable in its spirit as to be worth quoting in full:—

Under the consideration that it is due to enterprising men who first explore countries or large districts as much as possible to preserve the memory of their conduct in the names of the regions they discover, the Governor has been pleased to direct that the great coast divisions of the colony shall be hereafter distinguished as follows:—

1. The territory included between the southern part of the eastern boundary of the province, the Murray, Lake Alexandrina, and the sea to be called *Bonneia*.
2. The territory included between the Murray, Lake Alexandrina, Encounter Bay, and St. Vincent and Spencer's Gulfs, excepting Yorke's Peninsula, to be called *Sturtia*.
3. Yorke's Peninsula, of course, to retain the name originally given to it by its first discoverer.
4. The peninsula included between Spencer's Gulf in its whole length and the Southern Ocean from Cape Catastrophe to the western point of Denial Bay to be called *Eyria*.

In regard to the minor features of the country to which the natives may have given names, the Governor would take the present opportunity of requesting the assistance of the colonists in discovering and carefully and precisely retaining these in all possible cases as most consistent with propriety and beauty of appellation.

All information on this subject should be communicated in precise terms to the Surveyor-General, who will cause memoranda to be made of it and native names, when clearly proved to be correct, to be inserted in the public maps.

Very few persons have a genius for hitting on a really good name, and not many possess the faculty or gift that characterised Flinders when he suggested, in a modest footnote to his journal, the name Australia as preferable to New Holland or Terra Australis.

His Excellency Colonel-Governor Gawler, K.H., evidently had not this faculty, consequently the names he suggested have never become popular; but the practice he urged has not fallen into disuse so far as the Survey Department is concerned, for the present Surveyor-General has caused several thousand native names to be collected and officially recorded. But what use can these names be put to, we may be excused for asking, if, as the outlying country becomes settled, other names are substituted?

OUR OWN NAMES.

The coastal names of South Australia, with but few exceptions, are surnames bestowed by Flinders when mapping our shores in 1802. They perpetuate the names of the officers and crew of his ship *Investigator*, also of the Lords of the Admiralty, and other friends of his. A majority of the inland names have been introduced by settlers, dating from 1836, who made use of familiar names—English, Scotch, and German, according to their nationality; and associated them with the sites they selected for occupation.

Next to Flinders, we owe the greater number of names to Colonel Light, E. J. Eyre, Governor Gawler, and early explorers, all names of importance given by them having been confirmed by notices published in the *Government Gazette*, or by communications to the Home Government; also by being recorded upon official maps in the office of the Surveyor-General.

We find that names of places in South Australia frequently stand connected with circumstances in which individuals were placed, so that the events of a passing hour have thus left their impress in such names as Memory Cove, Cold and Wet, Happy Valley, Birthday Creek, and so on. They are often descriptive, either in a literal sense, as Mount Lofty, Holdfast Bay, Bald Hill, Brown Hill Creek, Ironstone Lagoon, Rocky River, or in a figurative sense, as the Sugarloaf, Tent Hill, Three Sisters, Biscuit Flat, Leg of Mutton Lake, the Punch Bowl, and the Devil's Elbow; whilst personal names have been generally applied to prominent natural features, as Mount Brown, Lake Albert, River Torrens, &c.

We have clearly, therefore, several sets of names, representing different classes of ideas—historical, descriptive, commemorative, and imaginative—having much in common with the classification of native names previously referred to; and it would be quite as difficult for us to explain to the aborigines the literal meaning of some of our best known names—as, for instance, North Adelaide,

Little Adelaide, Norwood, or Hindmarsh—as it is for them to enable us to understand the significance of some of their beautiful names, concerning which no glimmering appears even in the valuable vocabularies of Schürmann, Williams, Teichelmann, Meyer, Wilhelmi, Moorhouse, Eyre, Taplin, Wyatt, Gason, Smith, and Stephens.

COUNTIES.

The counties of the province of South Australia derive their designations from personages of exalted position—secretaries of State, Governors, and distinguished colonists—whose career has been intimately associated with its history. Thus it is that such notable names appear upon our maps as Adelaide, Victoria, Stanley, Russell, Carnarvon, Buckingham, Cardwell, Kimberley, Gladstone, Granville, and Newcastle, which are too well known to require comment; with the historical names (to us) of Flinders, Light, Sturt, Frome, and Eyre, mingling with those of vice-regal representatives, who, placed in order of their residence here, are as follows:—Hindmarsh, Gawler, Grey, Robe, Young, MacDonnell, Daly, Hamley, Fergusson, Hanson, Musgrave, Way, Jervois, Robinson, and Kintore, whose honorable service in the fulfilment of their high office has been recognised by the association of their names, for all time, with the chief divisions of the occupied portions of our territory. To complete the list of Governors, reference should be made to Lieutenant-Colonel James Harwood Roche, who was appointed Sir James Fergusson's *locum tenens* from March 4th to April 4th, 1870; also to Sir William Wellington Cairns, K.C.M.G., who administered the Government during a part of 1877, prior to Sir William Jervois, but whose names, up to the present date, remain an exception to the practice usually followed.

HUNDREDS.

Many of the sub-divisions of counties, called hundreds because they contain an area of about 100 square miles, bear the names of members of Parliament, irrespective of historical or geographical associations. Some have names borrowed from well-known natural features, towns, and mines; a considerable proportion have euphonious appellations, selected from appropriate native names within or adjacent to their boundary lines; several indicate warlike proclivities on the part of someone, such as Waterloo, Inkerman, and Balaklava. In seven cases, with strict impartiality, ladies of South Australia, and ladies belonging to vice-regal households, have been honored by the bestowal of their Christian names to a hundred square miles of land, as follows:—Anna, Grace, Jessie, Anne, Caroline, Joanna, and Blanche; but as official records do not disclose the identity of the persons to whom this distinction has been accorded, it has been necessary, in compiling the subjoined schedule, to obtain the information from private sources.

TOWNS.

The right of naming or approving of names proposed for Government towns is possessed by all the Governors in virtue of their representative character. From their pen the mandate issues, "Let the name be so-and so," and the name is fixed by proclamation in the *Government Gazette*; but future generations will be left to inquire in vain concerning the persons or places intended to be immortalised.

The composite names of Johnburg, Lucyton, Jamestown, Carrieton, Percyton, Snowtown, and Edithburgh are rather less intelligible than native names, and will have no charm of association for posterity. The same verdict may be pronounced upon names of places from across the sea transplanted into mallee scrub and working men's blocks, to blossom odorous with the memories of other days to the initiated, but odious to many who can find no reason for the name.

Out of a list of 400 post office towns in South Australia published in the latest directory only 25 per cent. have names selected from the native language, the greater number of them having been introduced from the older countries and also reproduced in the other colonies, whilst the remainder consist of the surnames of persons who formerly owned the land upon which the towns have been laid out.

ADELAIDE.

The request of King William IV., or rather his royal command, to the South Australian Colonisation Commissioners before any of them left England, that Adelaide, the name of his amiable and beloved consort, should be conferred upon the capital city of the new colony was a happy inspiration. The popularity of the name was testified to by interested groups of early colonists present upon the site near the beginning of 1837 when the survey of streets and allotments was officially announced as completed.

The choice of names for streets, squares, and terraces was in no less degree a marked success—a result which may probably be correctly ascribed to Colonel Light, conjointly with Sir James Hurtle Fisher and Governor Hindmarsh. A scrutiny of the names of the original streets, as marked upon the first official plan, discloses the fact that the names of the Colonisation Committee, of the founders, and of certain other noted men, who assisted by their enlightened views, their personal influence, and their votes in the House of Commons the passing of the Act authorising the settlement of the country, and who, by undertaking monetary responsibilities contributed largely to its ultimate success, were regarded as being worthy of such honorable remembrances. In sympathy with this idea I deem the present a suitable occasion for setting before this Science Congress, and through it the public, some items of information which may serve to bind more closely the name of the street and the person associated with it.

First we observe upon the map the names of two distinguished naval geographers, Flinders and Franklin, together in line, significant of the fact that they were companions in life. Parallel with them is the street bearing the name of Sturt, the explorer and discoverer of the Murray, whose report of good land west of that river first drew attention to the eligibility of this part of Australia for occupation. Our colonial historic names, Wakefield and Angas, represent the theory and practice of successful colonisation; Sir John Pirie and the Honorable Raikes Currie, Sir William Hutt, M.P., and Sir Richard Hanson well represent commercial life, stability, intelligence, ethics, and morals. Sir Richard Hanson's claim was valid, even before his career in the colony made it so, for as early as 1834 he identified himself with an association in London of a scientific and literary character which occupied itself with prospective colonial affairs, more especially those of South Australia. Carrington-street is named after Lord Carrington. To Sir Henry Ayers we are indebted for the information that Halifax-street is named after Mr. Hallifax, of Glyn & Co., and is wrongly spelt on the original plan.

The men after whom our squares are named are Light, Hindmarsh, Whitmore, and Hurtle Fisher (they surround the square named Victoria, and figuratively guard the young Princess Victoria, then heir-apparent to the throne of England), and Wellington, under whom Colonel Light had served in the Peninsula War, and by whom the latter had been recommended as Surveyor-General. In North Adelaide we are reminded of Lord Brougham, Sir Fowell Buxton, Daniel O'Connell, and several members of the South Australian Association in London.

The elements of tragedy and romance present themselves in the names of Sir J. W. Jeffcott, the judge who was drowned at the Murray mouth by the upsetting of a boat, and of Robert Quayle Kermod, whose daughter was engaged to be married to the judge.

The following schedule of names will speak for itself concerning the sagacity, discrimination, and magnanimity displayed by those who were authorised to give the names which have grown so familiar to our ears.

To Colonel Light alone belongs the credit of selecting the site of the capital, and, though much blamed at the time by some of the leading colonists, the verdict of posterity has ratified the choice.

NAMES OF STREETS IN THE CITY OF ADELAIDE AS LAID OUT BY COLONEL LIGHT, 1837,

AND ADOPTED ON PLAN FROM WHICH THE ACRE BLOCKS WERE SOLD.

(Kindly Revised and Corrected by Thos. Worsnop, Esq.)

Angas-street (George Fife Angas, one of the original Commissioners for South Australia), Barton-terrace (Barton Hack, one of the founders of South Australia, and a large purchaser of acres), Brown-street (John Brown, Commissioner of Immigration), Buxton-street (Sir Thos. Fowell Buxton, M.P., President of Aborigines'

Protection Society), Barnard-street (Edward Barnard, Esq., one of the Commissioners of South Australia), Brougham-place (Lord Brougham), Carrington-street (Lord Carrington, John Abel Smith), Currie-street (Raikes Currie, Esq.), Childers-street (J. M. Childers, M.P.), Finnis-street (Colonel B. T. Finnis, Assistant Surveyor-General, &c.), Franklin-street (Sir John Franklin), Flinders-street (Captain Matthew Flinders, R.N.), Gilbert-street (Thos. Gilbert, Esq., Comptroller of Stores), Gover-street (W. G. Gover, Esq., of London), Grenfell-street (Pascoe Grenfell, M.P., anti-slavery advocate), Gilles-street (Osmond Gilles, first Colonial Treasurer), Gouger-street (Robert Gouger, Esq., one of the Commissioners for South Australia), Grote-street (George Grote, M.P., one of the Commissioners for South Australia), Hanson-street (Sir Richard Davies Hanson, a distinguished member of the Australian Literary Society of London, and Secretary to the Governor of Canada), Halifax-street (Hallifax, of Glyn & Co., one of the founders of the colony), Hindley-street (C. Hindley, M.P.), Hill-street (Sir Rowland Hill, P.M.G.), Hutt-street (Sir William Hutt, M.P.), Hindmarsh-square (Captain Hindmarsh, R.N., first Governor of South Australia), Hurtle-square (James Hurtle Fisher, Colonisation Commissioner and Registrar), Jeffcott-street (Sir J. W. Jeffcott, Judge of South Australia), Jerningham (a banker, of London, connected with the scheme of colonisation), King William-street (William IV., King of England), Kermode-street (Robt. Quayle Kermode, his daughter was engaged to Judge Jeffcott), Kingston-terrace (Sir George Kingston, Deputy Surveyor-General, under Colonel Light), Lefevre-terrace (John Shaw Lefevre, one of the first Commissioners for South Australia), Light-square (Colonel Wm. Light, first Surveyor-General of South Australia), Mann-terrace (Chas. Mann, Esq.), Morphett-street (Sir John Morphett, who, with his brother George, was an agent for some influential people at home), Melbourne-street (Lord Melbourne, Prime Minister), Molesworth-street (Sir William Molesworth), Montefiore-place (Jacob Montefiore, Esq., Colonisation Commissioner), Mills-terrace (Samuel Mills, Esq., Colonisation Commissioner), McKinnon-parade (William Alexander McKinnon, M.P., Colonisation Commissioner), O'Connell-street (Daniel O'Connell, the celebrated Irish politician), Palmer-place (Colonel George Palmer, Colonisation Commissioner), Pirie-street (Sir John Pirie, alderman, city of London, Colonisation Commissioner), Pennington-terrace (James Pennington, Colonisation Commissioner), Pulteney-street (Sir Pulteney Malcolm, Admiral), Roberts-place (Josiah Roberts, one of the Commissioners for South Australia), Rundle-street (John Rundle, M.P., Colonisation Commissioner), Stanley-street (Right Hon. E. G. Stanley, Secretary of State for the Colonies), Strangways-terrace (T. B. Strangways, brother of Giles E. Strangways), Sturt-street (Captain Charles Sturt), Tynte-street (Colonel Kemeys Tynte, of Wales, a friend of Colonel Light), Victoria-square

(Princess Victoria, heir to the throne of England), Waymouth-street (Henry Waymouth, Esq.), Wakefield-street (Daniel Wakefield), Ward-street (H. G. Ward, M.P.), Wellington-square (Duke of Wellington), Wright-street (John Wright, Esq., Colonisation Commissioner), Whitmore-square (W. Woolryche Whitmore, M.P., Colonisation Commissioner).

SCHEDULE OF PLACES,

SHOWING BY WHOM DISCOVERED, DATES WHEN FIRST VISITED, AFTER WHOM NAMED, AND OTHER STATEMENTS.

Australia.—The Spanish navigator, de Quiros, in 1606, called this great southern continent “Terra Australis del Espirito Santo.” The Dutch Government, in 1644, gave it the name of New Holland. Flinders, in his journal of 1801-8, suggested the name Australia. Through the efforts of the Colonisation Commissioners, the name *South Australia* became legally connected with this province by Act 95 of William IV., dated August 15th, 1834.

Adelaide.—Named after the consort of William IV., by royal command. Native name, “Tarndanya.”

Althorpe Isles.—Named by Flinders, on the 20th March, 1802.

Antechamber Bay.—Named by Flinders, April 7th, 1802.

Alexandrina, Lake.—Discovered and named by Captain Sturt, February 9th, 1830.

Albert, Lake.—South of Lake Alexandrina, and connected with it by a narrow arm, which escaped the notice of Captain Sturt; explored and surveyed by Colonel Frome, Surveyor-General of South Australia. Named after Her Majesty's Royal Consort by Governor Gawler, in *Gazette* September 10th, 1840.

Augusta, Port.—This beautiful harbor was discovered in May, 1852, by Messrs John Grainger and A. L. Elder, they having, by permission of the Lieutenant-Governor, proceeded to the north end of Spencer's Gulf in the Government schooner *Yatula*, accompanied by a surveyor, Mr. W. G. Harris. After completing the survey of Port Fergusson, they proceeded up the gulf, and about three miles above Curlew Point discovered a very superior landing place due west of and about seven miles distant from Mount Brown. On the 14th May the *Yatula* was brought to anchor in the gulf abreast of the new port, there and then named Port Augusta. The report of Messrs. Grainger and Elder was published by command (in the *Government Gazette*, dated June 17th, 1852) of His Excellency Sir Henry Edward Fox Young, in honor of whose wife this fine harbor was named. The town of Port Augusta was surveyed in 1854, and the first allotments were sold on August 17th, 1854; the town of Port Augusta West being added eleven years later. The native name of the locality is “Kurdnatta,” meaning, it is said, “heaps of sand.”

Ardtornish.—Estate of Gregorson's, the outlawed McGregors. Miss Gregorson's father was a friend of Sir W. Scott, mentioned

in "Rob Roy" and "Lord of the Isles." Her nephews, Angus and Gillian McLean, lived there with Miss Gregorson. One went to Batavia, and was afterwards drowned in a cyclone; the other came back and claimed the property, and sold out about 1878.

Athelstone.—The property of Messrs. Wm. and Chas. Dinham. Here was erected the second flour mill in the colony, 1839. (*Register*, July 15th, 1893.)

Angus, River.—Discovered December 31st, 1837, by Messrs. Cock, Finlayson, Wyatt, and Barton, and named after Mr. G. F. Angus.

Acraman, Lake.—Discovered by Stephen Hack, August, 1857, named after Mr. Acraman, who, with Messrs. Main, Lindsay, & Co., took up the country adjacent in 1858.

Black Rock.—Named by Frome, November, 1842; *Gazette*, January 5th, 1843, p. 7.

Brown, Mount.—Named by Flinders, March 9th, 1802, after the naturalist, Robert Brown, who accompanied him on the voyage, and who named one of our favorite flowers and shrubs after his friend, the Right Hon. Sir Charles Francis Greville, Vice-President of the Royal Society.

Boston Bay.—Named by Flinders, February 28th, 1802.

Boston Island.—Named by Flinders, February 25th, 1802.

Bicker's Isle.—Named by Flinders, February 25th, 1802.

Backstairs Passage.—Named by Flinders, April 6th, 1802.

Bauer Cape.—Named by Flinders, February 5th, 1802, after Ferdinand Bauer, painter of natural history, on board the *Investigator*.

Bolingbroke Point.—Named by Flinders, February 26th, 1802.

Bank's Cape.—Named by Lieutenant James Grant, December 3rd, 1800, on board the *Lady Nelson*.

Bridgewater Cape.—Named by Lieutenant James Grant, December 4th, 1800, after the duke of that name.

Bernouilli Cape.—Named by Baudin, in 1802, in the *Le Géographie*.

Buffon Cape.—Named by Baudin, in 1802, in honor of the great naturalist.

Bonney, Lake (River Murray).—Named by Joseph Hawdon, March 12th, 1838, after Mr. C. Bonney, his fellow traveller; native name, "Nookamka."

Barker, Mount.—Named by Sturt, in honor of his friend Captain Collet Barker, of the 39th Regiment, who fixed its geographical position from Mount Lofty, on the 18th April. 1831, and was killed by the natives near Goolwa, on the 30th of the same month; native name, according to Revs. Teichelmann & Schürmann's vocabulary, is "Womma Mu Kurta."

Bryan, Mount.—Named by Governor Gawler on December 12th, 1839, after his young friend who lost his life in the locality whilst on a flying trip from the North-West Bend with the Governor and

one attendant. The weather was hot, water and provisions ran out, Mr. Guy Bryan's horse became unable to travel, and he was never seen again, although a search and aid party were quickly sent back from the river. *Vide Register*, January 4th, 1840; also 2nd Col. Com. Report, 1840-41.

Broughton.—Named by Eyre, May, 1839, probably after Bishop Broughton.

Barcoo or *Cooper*.—Mitchell's Victoria River, discovered and named by him in December, 1845, was mapped by his assistant, Ed. B. Kennedy, who traced it down, in 1847, to the boundary of South Australia, and found that the Thompson, which gathers its waters in the tropics, poured them into the Barcoo, and, gaining strength through several hundred miles, became identical with the Cooper of our territory, discovered and named by Sturt, October, 1841. The rival names—Cooper, Strzelecki, Victoria, and Kennedy, applied to various parts of the stream—became a vexed question, ultimately settled by the Imperial authority in a State paper. On the Cooper died the explorers Wills and Burke, not far from the present station Innamincka. The unfortunate Kennedy was speared to death, in 1848, whilst endeavoring to open a route between Rockingham Bay and Cape York; the only survivors of his ill-fated expedition being the naturalist, Carron, and Mr. Goddard.

Barossa Range.—Named by Colonel Light, 1837, probably after Barossa, in Spain, where the battle of that name was won by his friend Lord Lynedoch, in 1811. The second Colonisation Commissioners' report refers to a tribe of natives 100 strong at Barossa Range, in 1840.

Blanche Town.—Named after Lady Blanche MacDonnell.

Burra Burra.—Mine discovered October, 1845, on Burra Creek; named by coolies in the employ of Mr. James Stein; Hindoostanee for "great, great." Native name, Kooringa.

Borda, Cape.—Named by Baudin, 1802, after C. J. Borda, distinguished for his proficiency in navigation, mathematics, and physical science. His death, in 1799, was probably then unknown to Baudin.

Bremer, River.—This river was discovered at the same time as the Angas by Messrs. Robert Cock, W. Finlayson, A. Wyatt, and G. Barton, during an excursion to Lake Alexandrina, by way of Mount Barker; they named it the Hindmarsh, December, 1837, but as Messrs. T. B. Strangways and Y. B. Hutchinson proceeding simultaneously to Encounter Bay, keeping near the coast, discovered another river, which they also named the Hindmarsh, an official announcement upon the subject was made a year and a half later, as follows:—"Government order, No. 31, made June 26th, 1839, by His Excellency Captain Hindmarsh, R.N., and signed Geo. M. Stephens, Colonial Secretary.—His Excellency having observed that two rivers have been named the "Hindmarsh," one flowing into Encounter Bay, the other into the Lake Alexandrina, directs that

the latter stream shall in future be named the River Bremer in the public maps, in order to avoid confusion in the geographical description of localities in the province." It would have saved the compiler of this paper no little time and vexation had the information been then given that the name was selected in honor of Sir James John Gordon Bremer, K.C.H., formerly a lieutenant at Melville Island, afterwards in the *Alligator* or the *Britomart*, and founded the settlement at Port Essington in 1837.

Catastrophe, Cape.—Named by Flinders in 1802, on account of the loss of several men and a boat, on the 21st of February.

Corney Point.—Named by Flinders, March 18th, 1802.

Culver Point.—Named by Flinders, January 18th, 1802.

Carpenter Rocks.—Named by N. Baudin, 1802.

Coffin, Mount.—Named by Stuart, 1857-8, after a bullock-driver.

Coromandel Valley.—So named because the whole crew of a ship of that name, which arrived at the Port January 12th, 1837, deserted and hid in this locality until the ship sailed.

Cudlee Creek.—First settled in 1838; native name, "Kudlie," meaning dog.

Cock's Creek (now called Cox's Creek).—Named after Robert Cock, who, with five others, made the first attempt to find a passable track from the Tiers to Mount Barker, in June, 1838.

Coorong.—Seen by Messrs. Strangways and Hutchinson, December, 1837. First explored by Mr. Pullen, who with Dr. Penny, five boatmen, one policeman, and three natives, proceeded in a boat from Goolwa (or the Elbow) on the 29th and 30th July, 1840, to investigate the reported wreck of the *Maria* and the murder of her passengers by the natives (*vide Gazette*, August 13th, 1840). The name was officially reported by Major O'Halloran to Colonel Gawler (*vide Government Gazette*, September 10th, 1840). It had been several times entered by Mr. Pullen prior to this.

Cooper, Mount.—Named by E. J. Eyre, September 18th, 1839, after the Judge of South Australia, afterwards Sir Charles Cooper.

Cooper's Creek or *Barcoo* (see Barcoo).—Discovered and named by Sturt, October 13th, 1845, after Sir Charles Cooper. Mitchell, the explorer, subsequently called it Victoria River.

Chase's Range.—Named after Dr. Chase, who first visited Arkaba and Wilpena, 1851.

Capel Sound.—Named by Capt. Crozier after his Commander-in-Chief. (James' S.A., p. 287).

Currency Creek.—Named after the first boat that entered it, by T. B. Strangways and Y. B. Hutchinson, December 5th, 1837; native name, "Bungung." A large town was surveyed here for English proprietors.

Donnington, Cape.—Named by Flinders, February 25th, 1802.

Darke's Peak.—Locality where Mr. John Charles Darke was speared by natives, October 24th, 1844, when looking for good

country. He died whilst being taken back to Port Lincoln. His companions burnt a patch to efface the grave.

Dutton, Lake.—Named by Babbage, 1858, after F. S. Dutton (previously named Lake Gill, in 1846, by J. A. Horrocks).

Denison, Mount.—Named by Stuart, April 28th, 1860, after Sir William Denison, K.C.B.

Davenport Range.—Named by Stuart, May 29th, 1860, after Sir Samuel Davenport.

Discovery Bay.—Named by Mitchell, August 20th, 1836.

Dutton Bay.—Named after C. C. Dutton, killed by blacks near there, June, 1842.

Distance, Mount.—Visited and named by Eyre, September 1st, 1840.

Decres Bay.—Named by Baudin, 1802, who also called Kangaroo Island L'Isle Décre's.

Drummond, Cape.—Flinders, 1802, after Captain Adam Drummond.

Denial Bay.—Flinders, 1802, because he was denied a passage for his boat inland.

Encounter Bay.—Named by Flinders, April 8th, 1802, because he there met the French ship *Le Géographe*, which had approached from the south-east, engaged in similar work.

Elliot, Port.—Named by Sir Henry Fox Young, Governor of South Australia, 1850, after his friend the Governor of Bermuda (Lord Frederick Elliot). Declared a port, *Gazette*, June 17th, 1852.

Eyre, Mount.—Discovered by E. J. Eyre, and named by Governor Gawler, July 10th, 1839.

Everard, Mount.—Discovered and named by W. C. Gosse (subsequently Deputy Surveyor-General), November 2nd, 1873, after the Hon. W. Everard, Commissioner Crown Lands, P.P. 48 of 1874.

Everard, Lake.—Mapped by C. H. Harris, August, 1874, and named by Governor Musgrave, October, 1874.

Eyre, Lake.—Discovered by Eyre, 1839, and named by Governor Gawler.

Eliza, Lake.—Named by the Home authorities. Not shown on Wilde's map, 1833, but appearing on chart dated 1843.

Fowler's Bay.—Named by Flinders after his first lieutenant, January 28th, 1802. Here in November, 1840, stores were brought in the cutter *Waterwitch* from Adelaide, also, on January 31st, the *Hero*, cutter, put in her first appearance in lieu of the sister boat, transferred to service on the Murray, for Mr. Eyre, then on his overland journey to King George's Sound. Named also Port Eyre (Parliamentary paper, 129/1855, June 21st, 1858). Native name, "Yalata."

Flinders Range.—Mount Arden and Mount Brown, conspicuous points upon it, were named by Flinders in 1802; visited by Eyre,

May 18th, 1839; named by Governor Gawler (*vide Government Gazette*, July 18th, 1839), from latitude $34^{\circ} 18'$ northward.

Frome River.—Discovered by Eyre; named after the Surveyor-General, 1840.

Frome, Lake.—In the South-East. Discovered and named in May, 1844, by Mr. Burr, Deputy Surveyor-General, in company with Messrs. Bonney, Gisborne, and the artist (French Angas), after the Surveyor-General (Colonel Frome).

Freeling, Mount.—Named by Stuart, April 18th, 1860, after Colonel Freeling, Surveyor-General.

Field River.—Discovered by Captain Field, of Colonel Light's surveying staff, in 1837.

Flinders Island.—By Flinders, 1802, after his second lieutenant.

Freeman's Nob.—Named by whalers in 1836, after a Malay sailor, who brought in a vessel from Hobart by recognising the headland.

Freycinet Bay.—Named by Baudin, 1802, probably after his first lieutenant, afterwards the author of "*Voyage de Découvertes aux Terres Australes*."

Gambier, Mount, Lakes.—Visited by Governor Grey and Deputy Surveyor-General Burr, 1844; also then painted by Angas. Surveyed and sounded by Mr. Blandowski, 1851. Rev. J. E. T. Woods states in his "*South Australian Geology*," p. 227, that Captain Sturt probably gave Mr. W. G. P. R. James some information about them. Mr. Evelyn Sturt, one of the earliest settlers there, probably gave the information.

Gambier, Mount.—Named by Lieutenant James Grant, in the *Lady Nelson*, December 3rd, 1800, after Admiral Gambier. Native name, "Ereng Balam."

Gambier Isles.—Named by Flinders, February, 1802, after Admiral Gambier.

Grantham Island.—Named by Flinders, in 1802.

Glenelg.—Named by Governor Gawler early in 1839 after the Right Hon. the Secretary of State for the Colonies. Native names Patawilya and Cowandilla. A block of sixty-five acres at Holdfast Bay was granted to Mr. William Finke, March 23rd, 1839, which was laid out as a town by Messrs. W. Light and B. T. Finnis, Mr. Ormsby being the Surveyor-General. The original plan is interesting, as showing River Thames, and Governor Gawler's approval of the design.

Gulnare Plains.—Named by the discoverer, John A. Horrocks, in 1841, after a beautiful dog owned by him, that caught seven emus in five days. The name is said to be Moorish for pomegranate flower, and it occurs in Byron's poem "*The Corsair*."

Glenely River.—Discovered and named by Major Mitchell, July 31st, 1836. Native name, "Pawer."

Gawler Ranges.—Named by E. J. Eyre, September 18th, 1839, after Governor Gawler. *Gazette*, October 24th, 1839.

Gilles, Lake.—Discovered and named by E. J. Eyre, September 26th, 1839, after Osmond Gilles, first Colonial Treasurer.

Golden Grove.—Named by Captain Robertson early in the forties after his ship, and because of the appropriateness of the name to its surroundings.

Gumeracha.—Captain Randall, M.P., states that his father went to live at Umeracha, as then called, in 1839. The house was built close to a fine waterhole in the Torrens, which he thinks the natives called "Umeracha." The town was laid out on land belonging to the late W. B. Randall in 1860.

Gairdner, Lake.—Discovered by Stephen Hack, August, 1857, and simultaneously by Major Warburton, accompanied by his friend Samuel Davenport, Esq. Named by Governor Gawler, October, 1857, after Gordon Gairdner, chief clerk in the Australian Department of the Colonial Office.

Gregory, Lake.—Discovered by Gregory, coming southward when in search of Leichhardt, in 1858.

Glen Osmond.—After Osmond Gilles, first Colonial Treasurer. He owned land in that neighborhood.

George, Lake.—Name first appears on chart about 1840.

Hardwicke Bay.—Named by Flinders, March 19th, 1802, in honor of the noble earl of that title.

Hall, Mount.—Named by Eyre, September 18th, 1839, after the Governor's private secretary, Mr. George Hall.

Humilton, Lake.—Discovered and named by Eyre, October 28th, 1840, after his friend G. Hamilton, late Commissioner of Police.

Hindmarsh.—Town laid out on section owned by Governor Hindmarsh.

Hope, Lake.—Discovered and named by Messrs. Samuel and Robert Stuckey in 1859. Native name, "Pando."

Hindmarsh, River.—Discovered and named by Messrs. T. B. Strangways and Y. B. Hutchinson, December, 1837.

Hopeless, Mount.—Visited and named by Eyre, September 2nd, 1840.

Hallett's Cove.—First seen by John Hallett when searching for lost sheep, in 1837, with Daniel Cox. Hallett afterwards joined Captain Field at Mount Barker cattle station.

Hahndorf.—Named by German colonists after their friend Captain D. M. Hahn, who brought them to South Australia in the ship *Zebra*, December, 1838. It was laid out on a part of three sections bought from Messrs. Dutton, Finnis, and McFarlane at £7 per acre.

Horsnell's Gully.—Named after Mr. John Horsnell, who arrived here in the *Lysander*, July 6th, 1839, and went to reside in the Gully in 1842.

Hart, Lake.—Named by Babbage in 1858 after Captain John Hart.

Happy Valley.—Visited and named during December, 1836, by a party of several gentlemen.

Harris, Lake.—Discovered by C. H. Harris, August, 1874. Named by Governor Musgrave, October, 1874.

Hawdon, Lake.—Named by Messrs. Joseph Hawdon and Lieutenant Mundy, July, 1839.

Horrocks' Pass.—Named by John A. Horrocks, who passed through it August 16th to 19th. He was fatally wounded by the discharge of a gun, September 1st, west of Lake Torrens, but lived to reach Penwortham, where he died three days later. His camel was the first introduced into the colony.

Hurtle Vale.—Visited by a party in 1836-7; named after the first Commissioner of Lands, J. Hurtle Fisher. Native name, "Kowie Munilla."

Hindmarsh Island.—Named by Strangways and Hutchinson, December 6th, 1837.

Herrgott Springs.—Named after the botanist, Herrgott, of Stuart's exploring expedition, who discovered them in 1860.

Investigator Strait.—Named by Flinders, March 27th, 1802, after his ship.

Inman River.—Discovered and named by Messrs. T. B. Strangways and Y. B. Hutchinson, December, 1837, after Henry Inman, Superintendent of Police.

Jervis, Cape.—Named by Flinders, March 23rd, 1802. It was sketched by Mr. Westall, the celebrated landscape painter, who accompanied him.

Jaffa, Cape.—Named by Nicholas Baudin, in 1802.

Kangaroo Island (native name "Karta.")—Was named by Flinders when mapping the coast of South Australia, March 23rd, 1802. Here he secured thirty-one marsupials like those seen by Captain Cook in New South Wales, and, in gratitude for a seasonable supply of meat, adopted the name "Kangaroo." He left the island on April 6th, and two days after met the French captain, Baudin, in the corvette *Le Géographe*, who had approached from the south-east, engaged in similar work. As strained relations existed between England and France, Flinders cleared his vessel for action, but, receiving signs of peaceable intentions, he shortly after went on board, and next day named the water as far as could be seen either way "Encounter Bay." Having exchanged courtesies, and showed each other their maps, Flinders proceeded direct to Port Phillip, and Baudin, passing on presumably to the north side of the island, landed near Hog Bay, where it is supposed he left the hogs, from which the bay takes its name. He then, or some time later, cut an inscription on a rock about 6ft. high as a record of his visit, since known as "The Frenchman's Rock." The inscription is as follows:—"Expedition de decouverte par le Commandant (*sic*) Baudin sur Le Geographe, 1803*" (? 1802). Almost all the names on the south side of Kangaroo Island are

* The original figure was apparently 1802, a "tail" having been subsequently added to the figure 2, so converting it into 3.

French, as Baudin completed the survey of that portion and named it "L'Isle Decres." In 1819 Captain Sutherland obtained a cargo of sealskins and salt from this island. The oldest European settler (George Bates) arrived there in 1824, and by 1835, when William Thompson landed, there were seven male white settlers engaged in sealing and preparing wallaby skins for export. Thomas Waller—said to have been on the island since 1816—had assumed the title of governor; he gave up this title and sold his interest to the South Australian Company in 1836. An early settler, G. Meredith (whose father had a large business in Tasmania), took up his residence at Western River, on the north coast. On one of his trips across to the mainland he was killed by the natives while taking his supper by the camp fire at Yankalilla. The first vessel bringing colonists for South Australia, the *Duke of York*, arrived at Nepean Bay on the 29th of July, 1836, and Colonel Light, with his surveying staff, arrived in the *Rapid* on the 20th of August in the same year.

Kangaroo Head.—Named by Flinders, March 23rd, 1802.

Kingscote.—The first settlement on Kangaroo Island, named by Samuel Stephens in 1836, after Henry Kingscote, of London, according to instructions given him in England.

Kirton Point.—Named by Flinders, 1802. Since associated with the death of little Frank Hawson, who was speared by the natives, October 5th, 1840.

Kooringa.—Native name of the Burra Creek. *Vide* Burra for Hindoostanee origin. Our native words "boora boora" mean "far away," "by and by."

Louth Bay and Island.—Named by Flinders, February 26th, 1802.

Lincoln, Port.—Discovered and named by Flinders, February 26th, 1802, after his native town, Lincoln. He spent several days ashore, surveying, mapping, determining the latitude, longitude, variation of the compass, and dip of the needle. The site of these observations occupied a commanding view, which he described as exceedingly beautiful—an opinion shared by MM. Peron and Freycinet, of Baudin's expedition. The place is now marked by a white obelisk, erected by Lady Franklin, on behalf of her husband, Sir John Franklin, the illustrious explorer of the North-West Passage, to the memory of Flinders, under whom her husband had served as midshipman in the *Investigator*. Lady Franklin and her daughter arrived in the ship *Abeona* from Hobart, Captain Blackburn, who, with Messrs. Mitchell and Hawson, searched for and identified the spot known as Stamford Hill. The marble slab bearing the original inscription is now in the Adelaide Museum, having been replaced a few years ago by a similar one, bearing the following inscription:—"This place, from which the gulf and its shores were first surveyed on the 26th February, 1802, by Matthew Flinders, R.N., commander of H.M.S. *Investigator*, and the dis-

coverer of the country now called South Australia, was, on the 12th January, 1841, with the sanction of Lieutenant-Colonel Gawler, K.H., the Governor of the country, set apart for and, the first year of the government of Captain Grey, adorned with this monument to the perpetual memory of the illustrious navigator by John Franklin, captain R.N., Lieutenant-Governor of Tasmania." Colonel Light was blamed by some men of his day, less competent judges, for not placing the capital in this locality. Here Governor Hindmarsh put in (December, 1836) on his way to Holdfast Bay. Here, during 1840, four French whaling vessels put in; and in 1841 the Adelaide Fishing Company established a lucrative business. A town was surveyed on a suitable and elaborate design in 1840, the associations of the town of Lincoln being retained in local names. The aborigines of this locality have received more attention than those in any other part of South Australia, through the instrumentality in early days of the Revs. Schürmann, Meyer, and C. Wilhelmi, and later by the establishment of the Poonindie Mission Station a few miles north of the port, under Archdeacon M. B. Hale, afterwards Bishop of Perth.

Lowly Point.—Named by Flinders, March 9th, 1802.

Lofty, Mount.—Named by Flinders, March 23rd, 1802, upon viewing it from Kangaroo Head. Kangaroo Island. Captain Collet Barker, of the 39th Regiment, was the first European who traversed the plains between the seacoast and this notable feature of our landscape. He came here from King George's Sound, by request of the Governor of New South Wales, to examine the coastline with the view of ascertaining whether any navigable communication existed between the River Murray and the sea. Captain Barker arrived at Cape Jervis in the *Isabella*, April 13th, 1831, with Dr. Davis and Mr. Kent and a few soldiers, and skirted the coast to the mouth of a creek, which he named the Sturt, in honor of his friend, Captain Charles Sturt, who had shortly before returned to Sydney from his long expedition down the Murray. On the morning of the 17th, Captain Barker, accompanied by Mr. Kent and one man, set off to walk from Holdfast Bay to Mount Lofty. They reached the summit in good time next morning, and, having spent some time mapping the country east and north-east of the range, they returned to their boat on the 21st, much pleased with what they had seen. Nine days after, this highly-esteemed and capable officer met with a tragic fate, being speared by the natives whilst crossing the Murray, April 30th, 1831, near its sea mouth, and was never afterwards seen. His notes were taken care of by Mr. Kent, and became of great value to Sturt, who by them was enabled to satisfactorily complete his own chart, which had been vitiated by the supposition that a hill seen by him from the Murray was Mount Lofty, although he could not make its position in longitude agree with that in which Flinders placed it. In making use of Barker's memoranda, Sturt

availed himself of an opportunity for perpetuating, as far as he could, the name of a friend and companion, to whose inestimable worth he bore most eloquent testimony. A tablet with an inscription, placed in St. James' Church, Sydney, witnesses to the high esteem in which he was held by those who knew him. A cairn was erected upon Mount Lofty in 1840, in connection with the trigonometrical survey commenced by Colonel Light and carried on by Sergeant Forest. This cairn, which had become a landmark to seamen in approaching the anchorage in the open roadstead, was replaced in 1865 by an ornamental wooden structure upon precisely the same spot, capable of affording shelter to tourists. This, falling out of repair so that its position could not be identified from a distance, was replaced by the present substantial obelisk, suitable both for an observing station and a landmark for mariners; it was completed in November, 1885. The native name suggests that the aborigines saw in the outline of the range a fanciful resemblance to a crouching animal, of which this and the smaller hill to the northward formed the ears. Dr. Wyatt, late Protector of Aborigines, gave the name as "Yure Idla," the locality of the ears, whilst, according to the vocabulary by the Revs. Teichelmann and Schürmann, it is "Yurre," ears; "Idla," whelp. The little town of Uraidla, nestling among the eastern slopes, preserves in its name the sound and associations of the native words. From the summit may be seen, in clear weather, the Troubridge lighthouse and the eastern shore of Yorke's Peninsula, distant about sixty miles, whilst the obelisk is visible with a telescope from South Hummocks, near Port Wakefield, more than seventy miles away. The elevation of Mount Lofty above low water at Glenelg is 2,334ft.; its latitude and longitude, $34^{\circ} 58' 26''$ and $138^{\circ} 42' 23\frac{1}{2}''$ respectively. The approximate figures given by Flinders are such as to afford a striking illustration of the remarkable skill and accurate work of this distinguished navigator, for whom there exists no national memorial, and whose only monument in this land is that erected to his memory at Port Lincoln by Lady Franklin, *with permission*.

Liptrap Cape.—Named by Captain James Grant, R.N., December 19th, 1800, after his friend, John Liptrap, Esq.

Lannes, Cape.—Named by Baudin in 1802.

Lacepede Bay.—Named by Baudin in 1802. Called Port Caroline, because a vessel of that name, trading between Hobart and Adelaide, found good shelter there from a gale. The town of Kingston was surveyed here during December, 1861.

Lynedoch Valley.—Named by Colonel Light, December, 1837, after Lord Lynedoch, who won the battle of Barossa, in Spain, 1811. A most fertile district. Native name, "Putpa" or "Put-rayerta."

Lyndhurst, Mount.—Named by Mr. Samuel Parry in honor of the most eloquent Lord Lyndhurst, 1858.

Lady Blanche, Lake.—Named by J. McKinlay, December 31st, 1861, after Lady Blanche MacDonnell. Previously visited by Sturt in 1845, who camped near it and called it Lake Lipson, after Thos. Lipson, harbormaster.

Lake Eyre.—Discovered by Eyre, the explorer, 1839-40. Named by Governor Gawler.

Malcolm Point.—*Vide Gazette*, October 22nd, 1840. Surveyed by Frome. Named after Neil Malcolm, who took up the land there (special survey) in 1840. Surveyed by Col. Frome (*Gazette*, October 22nd, 1840).

Malcolm Point.—Named by Flinders, January 17th, 1802, in honor of Captain Pulteney, of the navy.

Marsden Point.—Named by Flinders, March 21st, 1802, after the second secretary of the Admiralty.

Maria Creek.—So named because of the wreck of the brigantine *Maria*, 36 tons, of Hobart, in Lacepede Bay, during July, 1840. There were twenty-six passengers, some of whom were drowned, and the rest treacherously murdered by the blacks while on their way to the Encounter Bay whaling-station. Major O'Halloran was sent to punish the natives; two of the most ferocious were hung at Pilgaru, where the mutilated bodies of several unfortunate victims were found. *Vide Register*, August 15th, 1840, and *Government Gazette*, September 10th, 1840.

McLaren Vale.—Named by David McLaren, manager of the South Australian Company, as successor to S. Stephens, when on a trip to Happy Valley, Hurtle Vale &c., in 1837.

McGrath's Flat.—Locality of native wells on the margin of the Coorong, where George McGrath was murdered, June 3rd, 1842, when on a trip to Portland Bay with two Europeans and four natives, who were said to have been forced to go beyond their tribal boundary line. The ringleader, Wirra Maldira, was captured, and was executed in Adelaide Gaol on March 29th, 1845. Given as "Werd-Maldara" in Boothby's Returns.

Mount Muirhead.—Named by Mr. Chas. Bonney, in 1838-9, after one of the party who accompanied him from Portland Bay to Adelaide.

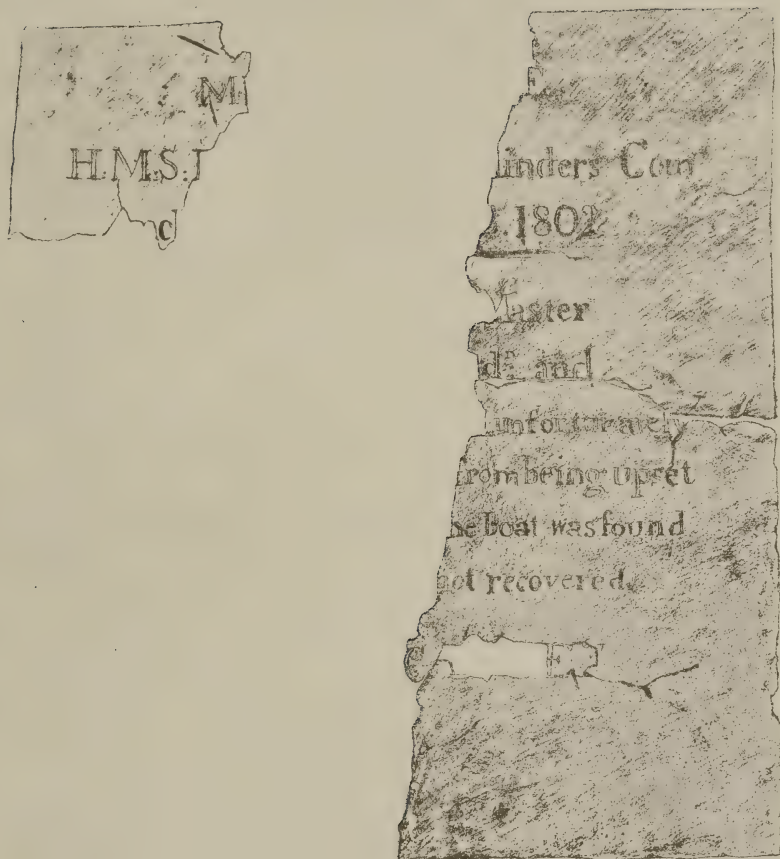
Macclesfield.—Named by F. Davenport, 1840, after his native town in England. Native name, "Kangooarinilla."

Memory Cove.—It was so called by Flinders in memory of a sad catastrophe which occurred there on Sunday evening, February 21st, 1802, he having lost two officers (Messrs. Thistle and Taylor) and six men by the upsetting of a boat, in which they had gone to find an anchorage. Flinders left an engraved copper plate affixed to a stout post at this cove informing future visitors of the disaster. A *fac simile* of three portions of the plate, now in the museum, brought to light by Dr. E. C. Stirling, F.R.S., under circumstances described by him in a paper read before the Royal Society of S.A., November 3rd, 1892, entitled "A Forgotten Relic of Australian

Exploration," will be found in Plate XVI. The size appears to have been 14in. by 12in., but the pieces required to fill the gaps have never been found. The exact words of the inscription are not recorded in Flinders' journal. The text suggested by Dr. Stirling is as follows:—"Memory Cove: H.M.S. *Investigator*, M. Flinders, comr.; anchored here Feb. 22nd, 1802. Mr. John Thistle, master; William Taylor, mid.; and six able seamen were unfortunately lost near this place from being upset in a sudden squall. The boat was found but the bodies were not recovered.C.A.....E." The words "in Thorny Passage," "in the ship's cutter" are suggested as alternative readings to "near this place"; but it is difficult to get a clue to the last line, having regard to symmetry and propriety.

Modbury.—Named by R. S. Kelly, September 1st, 1840, after his native town in Devonshire. Native name, "Kirra Ung Dinga," or "Kurra Un Dunga."

Murray, River.—The River Murray, the north-east portion of which was first named the Hume by Hamilton, Hume, and W. H. Howell, in 1824, now through its whole length bears the name of Sir George Murray, Secretary of State for the Colonies. This was in compliance with the known wishes of Sir Ralph Darling, and in accordance with Captain Charles Sturt's feelings as a soldier, who, on January 14th, 1830, discovered it as a magnificent stream unrecognised as a part of the Hume, and mapped it during a noted voyage occupying many months. The name of Sturt, who at the age of 17, as standard bearer, first carried the British flag into Paris, is most worthily associated with this noble river, both because of the circumstances attendant upon its discovery, and by reason of the literary merits of the volumes containing the account of himself and party whilst borne for so many months upon its waters. At its sea mouth is Port Pullen, a name now almost obsolete. There are, however, plans in existence showing that the name was applied to the region of the Murray mouth south of Goolwa, when, during the earliest years of colonial life, Mr. Pullen (afterwards Lieutenant, now Admiral) was employed by the Survey Department to "explore, sound, and map various intricate channels connected therewith." His report is published in the *Government Gazette*, September 17th, 1840. He entered the river from the open sea, September 6th, 1840, and through his exertions the cutter *Waterwitch* was brought in and taken up as far as Moorundie. Captain Blenkinsopp, of the whale fishery, Encounter Bay, had previously entered in a whaleboat on December 11th, 1837, but, with Judge Sir John Jeffcott and two of the crew, was unfortunately drowned next day whilst attempting to return. In close proximity to the eastern bank, and only a short distance from the ocean, is "Barker's Knoll," overlooking the site where the amiable and distinguished officer, whose memory it recalls, met with an untimely fate by the unprovoked attack of



FAC-SIMILIE OF PORTION OF AN ENGRAVED PLATE SET UP AT THE HEAD OF MEMORY COVE, NEAR PORT LINCOLN, BY FLINDERS, IN 1802; OF WHICH THREE PIECES WERE FOUND DURING 1866, AND ARE NOW DEPOSITED IN THE ADELAIDE MUSEUM AS A RELIC OF EARLY AUSTRALIAN EXPLORATION.

[Reduced to one-third original size].

the natives. Still a little further east is the spot where the brig *Fanny* was wrecked June 21st, 1838, fortunately without loss of life (*vide Register*, September 8th, 1838). The brig *Mariner* was also wrecked near here in November, 1845, being driven high and dry upon the beach, east of the Murray mouth, to the terror of the passengers, who all escaped, but were in fear of the natives, who had some years previously treacherously murdered the crew of the *Maria*, at a spot on the Coorong, not far distant.

Morgan.—Named after the late Sir William Morgan, M.L.C., April 25th, 1878.

McLeay, Point.—Mission station established October 4th, 1859. Named December 6th, 1837, by Messrs. Strangways and Hutchinson, after Mr. George McLeay, who accompanied Sturt. *Register*, January 20th, 1838.

Musgrave Ranges.—Named by W. C. Gosse, afterwards Deputy Surveyor-General, October 12th, 1873, after Governor Sir A. Musgrave.

Morris, Mount.—Named by W. C. Gosse, October 20th, 1873, after a personal friend.

Mylor.—Township named by Acting Governor Boucaut, April 27th, 1891.

Moorundie.—A police station on the west side of the Murray established, 1839, for protection of both Europeans and natives. E. J. Eyre, Dr. Moorhouse, and others occupied it in charge at different times.

Northumberland, Cape.—Named by Lieutenant J. Grant, December 3rd, 1800, after the duke of that title.

Nelson, Cape.—Named by Lieutenant J. Grant, December 5th, 1800, after his ship.

Neptune Islands.—Named by Flinders, 1802.

Nepean Bay.—Named by Flinders, March 21st, 1802, after the first Secretary of the Admiralty, afterwards Sir Evan Nepean.

Newland, Lake.—Discovered and named by Eyre, September, 1839, after Rev. R. W. Newland, of Encounter Bay.

Norton's Summit.—After the late Robert Norton, who, with his bullock dray, in 1851, was the first to scale this up to that time inaccessible hill. *Register*, June 17th, 1893.

Nairne.—Town surveyed September 16th, 1859. Named by the proprietor, Matt. Smillie.

Onkaparinga, River.—Discovered by Captain Collet Barker, April 17th, 1831, whilst searching the gulf for an outlet for the waters of Lake Alexandrina, crossing the bar in his boat; he records the name as Ponkepurringa.

Pearce, Point.—Named by Flinders, March 17th, 1802. Native mission established. A large town surveyed here about 1840, but never sold.

Pages, The.—Named by Flinders, April 7th, 1802.

Port Adelaide, Old.—The place where Colonel Light landed, and where the survey of South Australia was commenced in November, 1836.

Poonindie.—Mission station on Tod River established, October, 1850. *Vide Gazette*, October 31st, 1850, and February 5th, 1852.

Pirie, Port.—Named after Sir John Pirie and the vessel of the same name sold by him to the South Australian Company in 1835. Once known as Germein's Roads. So named by Governor Gawler in his report upon Mr. Eyre's exploration, August 13th, 1840. Solomon Town was laid out adjacent to present site in 1848. Government town of Port Pirie surveyed December, 1871, upon a novel design, adopted only in this instance.

Queen's Own Town.—Surveyed in 1867. Named after the 50th Regiment, to which Acting Governor Lieutenant-Colonel Hamley belonged.

Rivoli Bay or *Baye de Rivoli.*—Named by Baudin, in 1802. Native name for Rivoli Bay North, "Wirmal-Ngrang;" for Rivoli Bay South, "Wilichum."

Riley Point.—Named by Flinders, March 15th, 1802, after a gentleman of that name in the Admiralty.

Rapid Bay.—Colonel Light, on board the *Rapid*, anchored in this bay August 18th, 1836, and named it after the brig.

Reevesby Island.—Named by Flinders, March 6th, 1802.

Rosetta Head and Cove.—Named in honor of Mrs. G. F. Angas. In connection with a whale fishery at Rosetta Cove, about 1838-9, one party obtained 176 tons of oil.

Rawnsley's Bluff and *Chase's Range.*—Rawnsley's Bluff marks the termination of a survey made by Mr. H. W. Rawnsley, Assistant Colonial Engineer, during October, 1851, upon the running system explained and advocated in the second report of the Colonisation Commissioners. Mr. Rawnsley marked out a true meridian line from Mount Remarkable to Mount Eyre, and carried on his work as far as the point which bears his name, viz., to the Wilpena Pound, fixing in the course of his survey Mount Brown, Mount Arden, the Dutchman, the Devil's Peak, Wonaka Range, and Chase's Range, the latter being called after Captain Chase, who, shortly before, had walked all about that part of the country, living meanwhile with the blacks. Upon his representation, Messrs. Brown, Chambers, and others took up runs in the neighborhood.

Remarkable, Mount.—Named by E. J. Eyre, 1839, on account of the singular appearance it presented to him. It rises about 2,000ft. above the creek at its base, near which the town of Melrose is situated.

Schank, Mount.—Named by Lieutenant J. Grant, December 3rd, 1800, after his friend, Captain Schank.

Streaky Bay.—Named by Flinders, February 5th, 1802, because of the appearance it presented to him.

St. Clair Lake.—Name first appears on charts dated 1843.

Surfleet Point.—Named by Flinders, February 25th, 1802.

Stamford Hill.—Named by Flinders, February, 1802.

Spalding Cove.—Named by Flinders, February 26th, 1802.

Spencer's Gulf.—Named by Flinders, March 20th, 1802, in honor of the nobleman who presided at the board of the Admiralty when this voyage was planned.

Saint Vincent's Gulf.—Named by Flinders, March 30th, 1802, after Lord Vincent, of the Admiralty.

Semaphore.—The Semaphore owes its name to the fact that it was the site chosen for a signal station and landing place, in preference to Glenelg, about a year after the colony was founded. During October, 1849, the adjacent land was surveyed by the Government, several acres being set apart for the mail station reserves. The second report of the Colonisation Commissioners, 1840-41, contains the following reference to signal stations about this date:—"The telegraphs at the coast and on West-terrace are in full activity, announcing all vessels passing up the port, and, if they carry Marryat's signals, their names also." The report goes on to say that "a vessel, the *Lady Wellington*, carrying a light, with two pilots on board, has been moored at the outer bar for the convenience of large vessels making the port."

Sir Joseph Banks' Group.—Named by Flinders, February 26th, 1802, in honor of the President of the Royal Society.

Serle, Mount.—Named by Eyre, August 27th, 1840, in honor of a friend of Governor Gawler.

Sleaford Bay.—Named by Flinders, in 1802. A whale fishery was established here in 1839-40, which was successful for a year or so, until whales became scarce and the men deserted.

Sibsey, Stickney, and Spilsby Islands.—Named by Flinders, in 1802, after seamen drowned, February 22nd.

Sheaoak Log.—Settlement so called because of a sheaoak log left here, which had been used by Captain Bagot, early in the forties, with which to continue a plough furrow as a landmark after the plough was broken.

Strzelecki Creek.—Discovered by Sturt, August 18th, 1845. Named after Count Strzelecki. (*Vide State papers*).

Sturt Point.—Named by Strangways and Hutchinson, December 6th, 1837, in honor of Captain Charles Sturt, the veteran explorer. (*South Australian Gazette*, January 20th, 1838.)

Sturt.—Village. Named after Captain Sturt; surveyed at the suggestion of Sir H. Young, near Moorundie, about two miles south of Blanchetown; greater part now under water; originally the property of E. J. Eyre.

Sturt's Ponds.—The waterholes north of Cooper's Creek, visited by Sturt in 1845, and named by J. McKinlay, January 1st, 1862.

Talisker Mine.—Opened June, 1862, and named after a place in Scotland.

Tam o'Shanter Creek.—Named after the vessel *Tam o'Shanter*, which arrived at Port Adelaide on October 5th, 1836. "December 18th, 1836, at 11 a.m., the *Tam o'Shanter* struck on the edge of the western sandspit, having three fathoms of water under half her length. She remained until 22nd, about 4 p.m., when she was hove off, both crews assisting."—Extract from Colonel Light's diary.

Taylor's Isles.—Named by Flinders, 1802, in memory of the young gentleman, a midshipman, who was lost in the cutter with Mr. Thistle.

Thevenard Cape.—Named by Flinders, 1802. Name of compiler of plan in his possession showing Nuyt's Archipelago.

Termination Hill.—Named by Eyre, August 3rd, 1840. It is the southern extremity of a range, and marked the limit of his exploration north-westward, excepting the point he sighted and named Mount Nor'-West.

Terowie.—Native name of small creek upon which Messrs. Chewing & Hiles's station was built many years ago. Hundred gazetted July 20th, 1871; town named "Shebbear" August 9th, 1877.

Thistle Island.—Named by Flinders, 1802, after the master, John Thistle, who was drowned in the boat accident of February 18th. A whale fishery branch from Encounter Bay was started here in 1839-40. The men were soon after removed to Encounter Bay, where they deserted.

Thorny Passage.—Named by Flinders, 1802, because of difficult navigation and painful experience.

Tiers.—The forests in the hills facetiously called by S. Stephens "Tiers D'Etat"—"3rd Estate." *Vide* F. S. Dutton's book.

Tod River.—Discovered by Messrs. Hughes, Cock, James, Lucas, and others, May 20th, 1839, when exploring Spencer Gulf in schooner *Victoria*, Captain Hawson, on behalf of the Adelaide Association. Named after Robert Tod, of the party.

Torrens Lake.—Discovered by Eyre, October, 1839. Named after Colonel Robert Torrens. *Vide Gazette*, October 24th, 1839.

Torrens River.—Named after Colonel Torrens, chairman of the Commissioners for South Australia, by Colonel W. Light, Surveyor-General, in 1836. *Vide Gazette*, 1867. Native name at Adelaide "Karra Wirra Parri."

Troubridge Hill.—Named by Flinders, March 24th, 1802.

Troubridge Shoal.—Named by Flinders, April 1st, 1802.

Telford, Mount.—Named by Mr. Samuel Parry, trigonometrical surveyor, 1858, after his friend Thomas Telford, C.E. and architect, well known early in this century throughout England, Scotland, and Norway.

Victor Harbor.—Named, about 1839, by Captain Crozier, of H.M.S. *Victor*, who surveyed the harbor.

Virginia.—Town surveyed in 1858 for the proprietor, Daniel Brady, who so named it.

Victoria, Port.—Visited early in 1839 by party dispatched by the Adelaide Association in the schooner *Victoria* to explore St. Vincent Gulf. Extensive town surveyed adjacent about 1840.

Venus Harbor.—Now called Venus Bay. Named by the Admiralty in 1840. Mr. Cannan surveyed the bay during 1839 in the cutter *Waterwitch*, and it is supposed that the name is connected with that vessel.

Wakefield, Port.—Port Wakefield came into existence as a port early in 1850, although the river had been discovered and named by Mr. W. Hill in 1838. The offer of a lease of Crown lands at the site in question was the subject of an influential memorial, in March of 1850, to secure its withdrawal from sale, on the ground of its affording a dangerous monopoly and being likely to act prejudicially to the public interest, as the applicant, Mr. Walters, or others, would have it in their power to monopolise the whole of the carriage from the Burra mine and the neighborhood, and to prevent the access of drays to the section reserved and known as Port Henry. Whereupon it was ordered to withdraw the lease offered, and to survey a township for sale, water frontages for lease, together with other water frontages in portions not exceeding 400ft., and this was immediately proceeded with. Captain Freeling (Surveyor-General) and Captain Lipson (Harbor Master) both reported upon the matter, the latter stating that he had been accompanied both by Mr. Quin and Mr. Germein, who had expressed favorable views as to the eligibility of the proposed site for a harbor, with reference to depth of water, anchorage, safety, and ease of access (*vide Gazette*, March 11th, 1850.) Port Wakefield rapidly became a populous town, and a shipping place of considerable importance, the activity of its trade being stimulated by the shipment of copper ore from the Burra Burra mine, and other business connected with it.

Westall, Point.—Named by Flinders, February 5th, 1802, in compliment to William Westall, the landscape painter accompanying him.

Wiles, Cape.—Named by Flinders, 1802, after a worthy friend in Jamaica.

Wedge Island.—So named by Flinders from its shape, 1802.

Wakefield, River.—Discovered and named by Mr. W. Hill in 1838.

Wellington.—Named by Neil Malcolm, for whom a special survey was made in 1839-40. Native name of ford "Wirrum Wirrum."

Willoughby, Cape.—Named by Flinders, April 6th, 1802. There the erection of a lighthouse, called the "Sturt lighthouse," was commenced in 1851 and completed January 10th, 1852.

Willunga.—The names Hurtle Vale, McLaren Vale, Aldinga, and Willunga are connected with the early adventures of Messrs.

Barton Hack, J. Hurtle Fisher, Lieutenant Field, and others, who were among the first to examine the hill country skirting the coast south of the Adelaide plains. According to Mr. Bull, the first official excursion into the bush was undertaken in 1837, when a party (consisting of Colonel Light, J. H. Fisher, S. Hack, together with a guard of marines from the *Buffalo*) started for Encounter Bay, taking a Government bullock dray, a horse dray, and saddle horses for the party. Reaching Mr. Hack's sheep station, near the coast about twelve miles from Glenelg, they proceeded as far as Aldinga, and approached the foot of the ranges where the town of Willunga now stands; they then returned to Adelaide.

Walkerville.—Town surveyed on a section owned by Governor Hindmarsh, through his attorney, Captain Walker, merchant, of Adelaide.

Yorke's Peninsula.—Named by Flinders, March 30th, 1802, after Charles Philip Yorke, of the Board of Admiralty.

Young, Mount.—Named by Flinders, March 8th, 1802, in honor of the Admiral.

Yatala, Hundred—Yatala Vale.—A native name, officially recognised in 1836.

NATIVE NAMES OF PLACES NEAR ADELAIDE, AND IN OUTLYING DISTRICTS.

(S. & T. REFER TO THE VOCABULARY OF SCHÜRMANN AND TRICHELDMANN.)

Adelaide (Tarndarnya), S. & T.; Adelaide and surroundings (Tarndarnyungga), Wyatt; Torrens River, passing through the city (Karrau wirra parri), S. & T., (Korra weera), Cronk, and Wyatt; Torrens, at Hindmarsh (Karraundo ingga), S. & T.; Torrens, at Reedbeds (Witoingga), S. & T.; Torrens, throughout (Perre, Peere or Parri), Wyatt; Torrens, in flood (Yertala), T. & S.; Torrens, Neighborhood of (Perre ingga), S. & T.; Port Adelaide (Yertabulti), S. & T.; Port Adelaide, Old (Yertabultingga), J. Cronk; Port Adelaide, plain towards Adelaide (Mikawomma), S. & T.; Happy Valley (Wara), Schürmann; Green Hill (Walga purre), Schürmann; Glenelg, south from mouth of creek (Patawilya), S. & T. and Cronk; Glenelg Creek (Patawalonga), Meyer and Cronk; Glenelg, towards Adelaide (Cowandilla), Arrowsmith; Glenelg native camp, near Everard's (Kouandilla), Wyatt; Glenelg, Bay-road, half way to Adelaide (Ingurro), S. & T. and S.; Brown Hill Creek (Willa willa), S. & T.; Sturt River (Warriparri), S. & T.; Mount Lofty (Yurre idla), S. & T.; Macclesfield (Kangooarinilla), Angas; McLaren Vale (Tattachilla); Modbury (Kirra ung dinga), R. S. Kelly; Lyndoch Valley, and fertile districts about (Putpa or Putpayerta), S. & T.; Para River (Mulleakki), S. & T.; Hutt River (Parriworta), S. & T.; Noarlunga, or the Horseshoe (Ingurloingga), S. & T.; Onka-

paringa River (Ingangkiparri), S. & T.; Willunga (Willa ungga), S. & T.; Meningie (Meningie, mud), Taplin; Milang (Millangk, sorcery), Taplin; Mannum (Manumph), Riche; Currency Creek (Bungung), Riche; Aldinga (Auldingga), Wyatt; Aldinga Plain Echunga (Eechungga), Wyatt; Yankalilla (Yangkallilla), Wyatt; (Ingalti ingga) S. & T.; Rapid Bay (Patparno or Patpungga), Wyatt; Encounter Bay (Wirramu 'la), S. & T.; Alexandrina Lake (Parnka), S. & T.; Hindmarsh River (Yalla doola), Wyatt; Peeralilla Mount (Peeralilla), Wyatt; Wellington (Wirrum wirrum), Angas; Kangaroo Island (Karta), S. & T.; Murray River at Goolwa, by a Murray black (Yoorlooaia), Wyatt; Murray River at Goolwa, by an Encounter Bay black (Goolwarra koore), Wyatt; Murray River at Goolwa, by an Onkaparinga black (Parrungka perre), Wyatt; Murray River, near Blanchetown (Moorundie), Eyre; (Moorundi), Taplin; Murray River (Ingalta), S. & T.; Inman River (Moo oola), Wyatt; Inman River, by a Murray black (Moogoora), Wyatt.

NATIVE NAMES OF PLACES NEAR PORT LINCOLN.

(FROM VOCABULARY BY SCHÜRMANN.)

Lipson's Cove (Budlu), Stamford Hill (Kaityaba), Port Lincoln (Kallinyalla), Mount Hill (Korti purre), Boston Island (Kurilyelli), Louth Island (Yorunu), Cobbler's Friend (Hill), (Kulli purre), Mount Liverpool (Kurroalla), Kirton Point (Punnu Mudla), Sleaford Bay (Tannanna), Sleaford Mere (Kuya bidni), Point Bolingbroke (Kanyang kunu), Thistle Island (Nundalla), Mount Gawler (Kardinu).

LIST, WITH MEANINGS OF COMPONENT WORDS OF THE LANGUAGE IN USE BY THE ABORIGINES AROUND ADELAIDE WHEN THE COLONY WAS FOUNDED.

The terminations "ingga," "angga," "ongga," "ungga," also "illa," "alla," "ulla," denote that a subject is on, at, or near to a place. Verbs terminate in "andi," "endi," or "undi," *i.e.*, neuter, active, or causative. Anna, denotes motion; arra, alongside of, passing; barti, grub, insect in general; itya, denotes direction, intention, or going; ityangga, or eechungga, near to, a short distance from, or at a place; karra, red gum; kadle, or cudlee, native dog; kauwe, or koue, water for drinking (cowie); karadla, far off; parri, perre, or peere, river or creek; patte, clogged, boggy; pate, or pāte, swamp, gum tree; wirra, forest, bushes, wood; witto, reed, bamboo, flute, tube (wee-to); yerta, earth, ground, territory; yerlo, the sea; yoko, ship.

In closing this paper, permit me to say that no one will regret more than I the omission of so many names that might reasonably be expected to be dealt with herein. The paper was commenced about four months ago, but the work is too large for anyone single-

handed. I should like to see it taken up by a section of the Royal Geographical Society, who will, I believe, recognise in this paper an honest effort to improve our official records in this direction.*

I have gratefully to acknowledge help from Sir Samuel Davenport, in the advice he has given, and to Sir Henry Ayers, for information promptly supplied. My thanks are due to G. W. Goyder, Esq., C.M.G., for his kind co-operation; to the Town Clerk, for having kindly corrected my list of the persons after whom the streets were named; to Mr. Thos. Gill, for the full use of his books and memoranda; to Mr. J. W. Jones (secretary of the section), for original documents obtained by him for my use; to articles in the *South Australian Register*, and Mr. H. C. Talbot, for substantial help in looking up and noting references.



4.—FIJI.

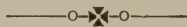
By J. P. THOMSON, M.A., C.E.



5.—GEOGRAPHICAL RESULTS OF THE ELDER EXPLORATION EXPEDITION TO CENTRAL AUSTRALIA.

By J. W. JONES, Conservator of Water, South Australia.

(WITHDRAWN.)



6.—LETTER FROM MR. CHARLES HEDLEY, F.L.S.

The Australian Museum, Sydney, N.S.W.,
August 21st, 1893.

Sir—At the instance of this section, the Admiralty was, to the benefit of geographers, induced to place upon the official charts the name of "The Tasman Sea," to designate that portion of the Pacific lying between New Zealand and Australia.

* At a general meeting of the Royal Geographical Society, South Australian Branch, held November 13th, 1885, Archdeacon Farr "suggested that the Council should endeavor, as far as possible, to ascertain the origin of the numberless native names of places in the colony and preserve a history of them."

It has occurred to me that students would be further advantaged were a distinctive name applied to that numerous and scattered group of islands between New Guinea and Cape York, Queensland. This group is sometimes vaguely and with circumlocution referred to as the Torres Straits Islands. This title has not, however, received recognition as a name or a place on maps. I would therefore suggest that this section approach the Admiralty with a proposal to call the group the "Torres Archipelago."

North and north-west from the Kermadec Islands there lies a vast reniform submarine abyss, stretching from S. lat. 21° to 32° , and from E. long. 174° to 179° , and whose floor averages a depth of 2,300 fathoms. This depression is shown in the map accompanying the narrative of the *Challenger*, but is there greatly exaggerated. For this basin I would suggest the name of "The Kermadec Trough."

I have, &c.,

CHARLES HEDLEY.

To the Hon. Secretary Geographical Section.



Section F.

ETHNOLOGY AND ANTHROPOLOGY.

1.—SMOKE SIGNALS OF AUSTRALIAN ABORIGINES.

By A. T. MAGAREY.

The discovery that no systematic effort had been made to gather and place in order the facts relating to the smoke signals of the Australian aborigines induced me to select this as the subject for a paper for the Section of Ethnology and Anthropology at this Science Congress. As the investigation and record of facts progressed the field constantly widened. Much information has been gleaned that cannot be presented in the limits of this paper; very much still remains to be gathered which it is most desirable should be conserved. The greatest obstacle in the way of obtaining the information required is the proud racial reticence of the natives themselves. The old men of the tribes, the priestly custodians of their tribal mysteries and secrets, guard most zealously, even from the younger men amongst their own race, the traditions and special knowledge confided to their charge. But now that this investigation has been initiated this priestly hesitancy may, perchance, be overcome, and interesting divulgements of their hoarded secrets be obtained from these wise old men.

The investigation has demonstrated that amongst Europeans very little was known of the existence amongst the Australian natives of any system of smoke signalling; whilst their wonderful proficiency in the art was known to only a very small circle of the white men. The information presented has been very carefully tested, has been accepted only from entirely reliable sources, and the most valuable and interesting facts have been supplied by eye-witnesses of what they describe, or who were in the localities at the time of their occurrence. The chief witnesses are men who have been members of some of the most famous Australian exploring expeditions, or have themselves been explorers of good experience, or bushmen who have been in contact with the aborigine in his wild state, and who from long experience were able to testify intelligently of what they had seen. So that there is no room to question the authenticity of the facts. The novelty and seeming incredibility of some of the statements demand this explanation in advance. Anyone at all acquainted with the exceeding inflammability of most of our Australian flora will, upon

consideration, realise that what may at first sight seem incredible and impossible is after all of quite common occurrence in all bush fires: that effects seen in uncontrolled power and beauty accompanying such fires quite possibly may be and, as a matter of fact, are systematically and methodically employed and controlled by our despised but intelligent natives.

The use of beacon fires and signal smoke can be traced back to the infancy of nations. The mountain peaks of Persia bore aloft her warning signals in the remote past. In the *Agamemnon* of Æschylus, the Greek commander is represented as communicating the intelligence of the fall of Troy to his Queen, Clytemnestra, at Mycenæ, in the Peloponnesus.* In Palestine the southern hills showed similar signals.† Hannibal employed signal smokes to outwit the Gauls at the Rhodanus (B.C. 218). In England and Scotland such signals were in constant use.‡ The Indians of California, the Apache warriors, and the Comanche Indians were and are proficient in the use of smoke signals. Speaking of the last, Mr. Bancroft says "there is used everywhere on the prairies a system of telegraphy which perhaps is only excelled by the wires themselves."§

So, too, the Australian aborigine is found to be in possession of a marvellously efficient system of smoke signals. Indeed, it was from seeing these smokes that Captain Cook first learned that Australia was inhabited.|| On the afternoon of Friday, the 20th day of April, 1770, the smoke signals, as they were sent whirling up into the soft cool air, were taken as proof, by the lion-hearted Cook, that the land (Australia) he had discovered but yesterday was the home of a new race of humanity; and the same smokes spoke to the ever-wary eyes of these nomads of the wilds of the presence upon their southern seas of a strange big "canoe" with white bird wings spread out to the southern breeze, and the warning sped on from point to point along the coast. From Cape Howe to Vlaming Head, from the York to the Leeuwin, through and across all Australia, adventurous voyagers and explorers have been ever greeted by the smoke-flags of the watchful native.

Flinders, A.D. 1823, when exploring Spencer's Gulf, judged, by the signal smokes to the north-eastward, that the natives there were numerous, and dwelt in a land of plenty. Sir George Grey, A.D. 1830; Eyre, 1840; Mitchell, 1832, on the Darling; Sturt, 1845; Stuart, 1862—explorers all—were greeted with these signals as they traversed the hitherto uninvaded territory of the Australian blacks.

* Chambers's Encyclop., vol i., p. 813.

+ Jeremiah, chap. vi., v. i.

‡ Chambers' Encyclop., vol i., p. 813.

§ H. B. Bancroft, *Native Races of the Pacific States of North America*, pp. 380, 497, 519-20, vol. i.

|| Lieutenant Cook's *Voyage Round the World*. First voyage, vol. III. pp. 485, 510.

All over Australia the native bore with him, as he roved, his spear, his boomerang, and his firestick. Whenever occasion required, he sent rushing into the upper air his token of warning or welcome, of invitation or defiance. of sorrow or rejoicing. Comrades in the chase were summoned to aid in the pursuit of bounding boomah or flying euro. Friends were warned away from dried-up well or empty rockhole, or bidden to the gladdening waters of the big lagoon, rich with fish in its depths, shellfish in its banks, fowl on its shaded bosom, with emu, wallaby, and kangaroo in the sturdy bush that grew around it.

The smoke signs were read with keen watchful eyes, as they bade to the feast, the dance, the camp fire, or the weird and wild corroboree; or warned the braves that dusky warriors were on the war-path; that blood, and blood alone, could meet the stern demands of native law and justice. Everywhere the Australian has ready to his hand the wherewithal to raise his smoke-flagged message. Piercing spinifex, spreading bush, waving grass, twisted rush, all roll out to the heavens the thought of his heart at the thrust of his firestick. The flame-tipped firestick is the sceptre wherewith he rules the bush world. Zealously treasured tradition, long experience, and constant practice have made him an accomplished adept at distance signalling.

The course of procedure is generally as follows, varying chiefly with the short-distance signals. When a message is to be sent the signal fire is raised. The eyes of the Australian aborigine are ever on the alert, and the presence of a smoke in the range of vision is almost instantly detected. At once the native is all attention, and every variation of the smoke-form is noted and intelligently interpreted. Should the signal require reply, a reply signal is quickly raised; and if the message is one to be passed on the signal code is promptly repeated. By this means messages are promptly and accurately forwarded from point to point, over hundreds of miles of distance, in a wonderfully brief space of time. Variations of the signal are made by various means—the color, or hue of the smoke; the size of the column raised; the more or less rapid change, when change is made; the time of day at which raised; the site of the signal. Commoner and unimportant signals last only a minute perhaps, and are raised anywhere. Long-distance signals require a larger, denser volume of smoke, more careful and elaborate manipulation, and are maintained generally for a longer space of time. Anyone devoting attention to variations of smoke-form, and especially if he will institute experiments, will quickly learn to detect numerous changes of form where formerly nothing of the kind arrested attention; they were there, but were not seen.

The Australian aborigine obtains his fire by the process, frequently described, of rapidly rubbing together two dry pieces of wood. Materials for his purpose are sufficiently abundant all over

Australia. For the purposes of signalling the following are those most generally in use, viz.*:—

- (A)—A slender column of pale-hued smoke.
- (B)—A heavy column of pale-hued smoke.
- (C)—A slender column of black or dark smoke.
- (D)—A heavy column of black or dark smoke.
- (E)— { A spiral coil-form of pale smoke.
 { A spiral coil-form of dark smoke.
- (F)—Interrupted or intermittent smokes, *e.g.*, in form of cut-off sections of smoke; side puffs of smoke; “balls” (or “balloons or cloudlets”) of smoke; parallels of smoke, either from the same fire or from adjacent fires; two or more in line.
- (G)—Groups or clusters of smokes. The individual smokes may be alike, or may be of different form or hue, and together convey code-meanings. Festoons of smoke are also used.

The following are the methods of producing the smokes specified, with the names of tribes using them, their code-meanings so far as yet learned in the localities named, and illustrations of their use:—

(A)—SLENDER COLUMN OF PALE-HUED SMOKE.

Produced by use of dry material, gum leaves, spinifex, dry grass, dry wood—a small quantity. A short-distance signal.

Powell's Creek Tribe.—One thousand four hundred and fifty miles north from Adelaide; native name of tribe, Warramunga, extending from Powell's Creek to Attack Creek. A piece of hard wood 12in. long, “tarunga,” is held steady on the ground; another piece of hard wood, “tarramee,” by friction causes smoke to appear on the “tarunga.” Powdered grass, “bigera,” is placed by the “tarunga,” and the flame raised by blowing with the mouth on the heated touchwood. The fire, “bobar,” is then made of grass, “bigera,” and bushes, “nanullo.” When a native first notices the smoke rising from a distant signal he says “bobar,” fire, “wahjungieto wahjo,” look out smoke. The pale thin smoke is named “bobuckbee,” meaning “one fellow sit down ill, send a man!”—a distress signal; the sick signaller is named “Boggo-lunnie.”

Barrow Creek Tribe.—The signal means “We are bringing a young man to be initiated into the full rights of the tribe”; his coming of age.

* The information concerning the Smoke Signals of Central Australian Tribes named below has been supplied (through the kind courtesy of Sir Charles Todd, K.C.M.G., Superintendent of Telegraphs, South Australia) by the following gentlemen, viz.:—

Barrow Creek Tribe, by Mr. J. McKay, stationmaster, Barrow Creek Telegraph Station; Macdonnell Ranges Tribe, by Mr. F. J. Gillen, stationmaster, Alice Springs Telegraph Station; Powell's Creek Tribe, by Mr. W. C. J. Tracey, stationmaster, Powell's Creek Telegraph Station; Tennant's Creek Tribe, by Mr. Scott, Tennant's Creek.

Macdonnell Ranges Tribe.—Native name, "Quoorta," means "I am going away." Signal made of dry grass.

Tennant's Creek Tribe.—Native name, "Mydoocoolooungwan," meaning "Come up, we are camped here hunting." The signal is only made when the natives are a short distance apart. In hunting, when a kangaroo is sighted the hunter raises the signal and repeats it during the chase. His comrades thus note the course taken and go to his help, or a lubra will take a "koolamon" of water and refresh him for the chase. The signal is also used as a warning of the presence of an intruder—explorers, for instance.

*Mr. Chas. Winnecke says of this pale signal that he has noted invariably that it is raised when a blackfellow discovers the presence of strangers and explorers, the smoke not lasting many minutes; generally being repeated at a little distance from the first point. It is used as a small vanishing form of signal, presumably to inform friends in the immediate vicinity—members of his own family or tribe—of the presence of the stranger. Being used when natives are watching intruders, the signals start up in different directions and at different points, shifting to accord with the position of the person watched. Mr. Winnecke says, "I should term these warning signals."

(B).—LARGE OR HEAVY COLUMN OF PALE-HUED SMOKE.

Produced by the use of a large quantity of dry material, or pale-smoke-producing fuel. A long distance signal.

Powell's Creek Tribe.—This smoke is named "Ohbobo-boobah-what-thung-gutto," and means "A friendly tribe is coming to yabber."

Barrow Creek Tribe.—The meaning is "Blackfellow dead." The fire is made on a sandhill. A large heap of grass is gathered, with a long train leading away some distance for lighting the heap by. When ready for lighting, the firing native turns his back on the heap, lights the train, and then runs away without looking back. This mode of lighting by a train at a distance with the back turned is owing to the superstition that the dead may see and recognise the native who fires the death-beacon.

Macdonnell Ranges Tribe.—Native name of signal "Alkninka quoo," meaning "Big light." Its message meaning is "Come at once." Material used, dry grass.

(C).—SLENDER COLUMN OF DARK (BLACK) SMOKE.

Powell's Creek Tribe.—Native name, "Hugullo," and indicates "A messenger from another tribe come growl" (*i.e.*, with a complaint, or threat of war). They make a similar smoke in reply, and send

* Mr. Charles Winnecke, explorer, Adelaide.

forward one of their youths (called Go-wurree) carrying with him a small bundle of bark and sticks tied together (called Goolwah), which he presents to the messenger of the attacking party.

Barrow Creek Tribe.—This signal means "Come here, we want to speak to you." It is made for the purpose of gaining information of the main camp of blacks. The signal is made of porcupine grass (spinifex) and myall bush, piled in round heaps, but small in size.

Macdonnell Ranges Tribe.—The smoke is named "Quoorta" (smoke), and means "Coming back," as in an unsuccessful search for water, when those out searching desire to prevent others from going so far out into dry country. Material used for producing the signal, green spinifex.

Tennant's Creek Tribe.—Native name of the smoke is "Nappamini-kedi," means "Little water here, don't come! Go back." The signal is made in one spot, and is kept up for hours.

(D)—LARGE DENSE COLUMN OF DARK (BLACK) SMOKE.

Produced by firing a large quantity of fuel, with green bushes, or spinifex, or damp material, so as to raise a body of dark smoke. Pre-eminently the long-distance signal of Australia, rising to a height of 1,500ft. to 2,000ft., according to some witnesses; and to 3,500ft. to 5,000ft., according to others. When dense spinifex is fired under sultry, still weather conditions—as it is by preference—the latter height is easily possible. Mr. Charles Winnecke states that boughs of growing acacia bush are broken off and thrown upon rank-grown spinifex, as found growing in a dip between sandhills, when a dark, high, towering column is wanted. *Netoon, a Moorundie (Murray River) native, states that the natives there would signal New South Wales border blacks on the river by means of three intermediate smokes, averaging some sixty-five miles range apart. With a wind moving gently, a strip of spinifex, some half-mile wide and one mile long, would be fired at its windward end. The smoke would continually rise higher into the air as the flame swept on down through the growth, till at length the signal would very far exceed in height the ranges near Adelaide. He adds that such a signal invariably, under the meteorological conditions named, so interfered with the atmospheric equilibrium as to be followed by cloud, wind, thunder, lightning, and rain. Investigation in this direction might yield very interesting and valuable results.

Powell's Creek Tribe.—Native name "Gubberil," means "Native sit down, look after kangaroo and emu"—a native is at that point watching game.

Barrow Creek Tribe.—The signal indicates a message telling comrades that a large number of natives is coming up; that they

* Charles Netoon, Moorundie aborigine, Murray River.

are travelling with the intention to kill another native belonging to a distant tribe.

Macdonnell Ranges Tribe.—Tribal name of smoke “Anjura quoorta” (big black smoke)—“Blackfellow dead.” Materials used, spinifex and gum.

Tennant's Creek Tribe.—Tribal name of smoke, “Mulla-wa-coola.” It indicates “Plenty of water here; preparing for a corroboree; plenty of game.” This signal is seen at great distances.

Powell's Creek blacks say that they can see and read the meanings of smoke signals distinctly from Renner's Springs, that is, twenty miles and over; and that they can distinguish smoke signals from Newcastle Waters, fifty-six miles distant.

Concerning Barrow Creek tribe: Ordinary signals are observable at about twenty miles distance; but the large dark signal at about sixty miles distance, on account of its forming a cloud appearance at the top of the smoke column. This form of signal was used by the native police tracker (who gives much of this information) after travelling two days and nights, which would be a distance of about eighty miles. This signal of the tracker was answered by his mate from his starting point in probably twenty minutes. Elevations are generally used in cases of distance signalling.

In the Macdonnell Ranges country the distance at which signals are seen, when blacks are travelling into Tennant's Creek Station, is about fifty miles, but the distance varies according to the nature of the country and the wind

* About two years ago (1891) or less a black boy died at Eringa Station during the afternoon, and next morning the fact of the death and the boy's name were known at the Alleumba Station, eighty miles distant; the intervening country being heavy scrub and there hence no previous intimation to prepare anyone for such news, so far as the informant could discover. The basis of such signals consists of puffs of smoke at various intervals, and continued for a greater or lesser length of time; further marked by peculiarities of appearance relative to the direction of the wind then prevailing.

† To the east of Barrow Creek Telegraph Station, on the Sand-over River country, amongst other means used to raise the large dark smoke signal, the custom is to fire large plots of luxuriant growth of grass, having previously overlaid the grass with green boughs broken from the adjacent acacia bushes, or a place thickly overgrown with a peculiar succulent acacia may be selected. This acacia contains a large proportion of resinous properties, and burns very freely even when green. The natives have been known in one instance to follow an explorer closely for some forty miles (two days), constantly raising columns of light (the rapid) smokes, and

* Communicated through Mr. C. Hope Harris, Survey Department, Adelaide

† Mr. Charles Winnecke, explorer, Adelaide.

by this means collecting the scattered members or warriors of the tribe. Finding themselves unable to keep pace with the white man, on the fourth day immense columns of dark smoke were raised in rapid succession along the course of the Sandover River, stretching across a tract of country 100 miles in length, the nearest smoke column being over fifty miles distant. Evidently the river formed the western and southern boundary of the tribal territory, and the natives were informing their friends that the intruder had departed into the territory of the range tribe to the westward. These huge dark columns of smoke rose majestically into the upper air, ultimately assuming at the apex a cumulus cloud form, at a height of 1,500ft. to 2,000ft. As the smoke column rose from the burning material the color was exceedingly dark. In the upward rush this dark hue was merged into a paler hue, and high aloft into a steamy white; still higher the pure white continued, till, spreading out as the due point was reached, a huge cloud-form was assumed. This cloud-form reached its maximum altitude right above the smoke column. This rank of giant signals, rushing up so regularly and suddenly, and with such rapidity assuming the graceful form described, gradually outspread aloft and merged into immense clouds, overshadowing the whole horizon. The whole effect was an apparent climax of aboriginal spectacular display in demonstration of their joy that their soil was no longer sullied by the foot of the stranger.

(E)—SPIRAL COILS OF THIN PALE (OR OF DARK) SMOKE.

There are several methods of artificially producing the spiral effect from an ordinary smoke column, though, as hereafter described, certain peculiarities of vegetable growth produce, when fired, similar effects.

Powell's Creek Tribe.—Native name of signal (pale smoke), "Mullagar winlabardin," meaning "All about, come quick, plenty of kangaroo." Similar coils of dense dark smoke, "Unbarunnie," mean "Two men come quick, help carry game."

Barrow Creek Tribe.—A thin pale coil of spiral smoke—a husband notifies that his lubra is dead. Manner of producing the signal—a circular fire of grass, with a large log of wood in the centre, is constructed, having a train (for use in lighting the fire) leading away from the material for the fire, about twelve yards in length. This form of signal is generally raised in scrub and close to a white gum tree.

Tennant's Creek Tribe.—A dark spiral coil. Native name of the signal, "Talla paramunda," meaning "We are travelling and hunting."

Port Darwin Tribe.—Signal of pale color. *In 1869, when the survey of the Port Darwin country was in progress, and only a small portion of the men were at Fort Point main camp, the officer

* G. W. Goyder, Esq., C.M.G., Surveyor-General, Adelaide, S.A.

in charge was one day informed that war signals were being raised by the natives. Ascending an adjacent hill to investigate, two spiral coils of light smoke were observed, the spiral form being given to the smoke by the blacks. Skins held by two natives were kept turning with a circular motion in an inclined plane over the rising smoke, so as to cut the column at each revolution of the skin, and so give a spiral motion and form to the smoke column as it rose, the fire being of dry wood. In the afternoon of the day on which these signals were made only three blacks were at the camp, but at daylight next morning between 600 and 700 natives surrounded the camp. These had crossed Port Darwin in their canoes by moonlight during that night. The warriors were painted and fully armed, thus showing that the previous day's signals were understood and responded to.

† A large high-towering signal smoke, with an upward whirling motion, and of singular whiteness (raised from spinifex) was observed some thirty miles south of east from the Everard Ranges. A native showed afterwards the method of raising the signal. Gathering a pile of very dry spinifex, after firing it, he whirled round the growing flame a heavily foliaged bough, gradually bringing the upward circlings to a point above the pile. Thus a whirlwind motion was imparted to the air, and so to the uprising heated air and smoke from the burning spinifex. Mr. Charles Winnecke says:—"I have noticed both the spiral and intermittent forms of smoke, both raised for a special purpose by the selection of, by growth, specially formed bushes, or bunches of grass and spinifex, so turned and twisted by the action of the wind that, by setting fire to them at a carefully and specially selected point, the various degrees and forms of smoke will be emitted. The blackfellow's acuteness in instantly observing those traits of nature most serviceable to him at the moment enables him readily to select the bush adapted to his purpose. I have seen it too frequently to assume it to be an accidental production."

The spiral form of signal seems the one most puzzling to those who find the idea of such a form novel. But if the upward rushing force of the heated air and smoke secure a boring whirling motion of 25ft. to 50ft. let it be supposed that the whirling motion is then lost, the smoke, though now itself inert, being borne aloft would still maintain the spiral form it had first assumed. Conceivably a body of smoke (be it of what form it may) borne aloft in an upward current of heated air would maintain that form unless the atmospheric conditions altered so as to play upon its form and change it. The steam from a locomotive in humid conditions of the air, especially in still air, maintains the shapes in which it is delivered into the atmosphere for a quite considerable space of time, and for a distance amounting to hundreds of yards from the chimney that emitted it. The simile is *apropos* only to a limited

+ Mr. V. H. Edwards, Giles' Exploring Expedition, 1882.

extent, but quite so as to permanence of form for a distance and time sufficient to permit of the signal being noted and interpreted. An American locomotive starting from rest gives a quick strong "chump," and emits from its chimney, with constantly increasing rapidity, a succession of clear cut steam rings, each ring revolving with immense velocity upon its own annular circumferential axis. At a short distance the characteristic form of these rings is readily recognisable. An experienced enginedriver, however, seeing these rings at a long distance, and at a height at which the clearly characteristic form had merged into one of considerably different appearance, would nevertheless recognise the creation of the locomotive, and know that it had borne the form above described when first emitted. So, too, the native and the spiral smoke signal. He recognises, even in the higher upper air, a form of smoke which must originally have possessed all the characteristics of the distinctly spiral form, though now the smoke he sees may vary slightly from that form, and he so interprets it.

(F)—INTERRUPTED OR INTERMITTENT SMOKES.

Smokes which are used in the form of cut-off sections or suspensions of the columns, side-puffs of smoke, balls (balloons or cloudlets), parallels of smoke, whether raised from the same fire or from closely adjacent fires a few feet apart, or two or three or more in line at one spot.

INTERRUPTED COLUMNS OF SMOKE.

Powell's Creek Tribe.—Native name of signal, "Madingall," meaning "Plenty kangaroo track, me follow till dark."

Barrow Creek Tribe.—Informing outside natives that the men are leaving all lubras at camp. Only blackfellows allowed to travel. Means used to produce the signal—balls of grass tied with blackfellow's hair-string, and these are lighted at intervals.

Tennant's Creek Tribe.—Native name of signal, "Coola," and means—"We are travelling to a certain water"; going to initiate a young man; signalling blacks to assemble. The signals are raised at short distances apart, to denote the direction in which the main body is travelling.

* *Port Darwin Tribe.*—Ball or balloon signals are produced as follows, *i.e.*, the dark smoke is collected in a skin, held in the form of a bag inverted over the rising smoke; when the bag is full of smoke one of the blacks who has been assisting releases the higher end of the bag, whilst the other gives an upward tendency to the collected smoke by throwing his arms up and allowing the contents of the skin to escape in the rising column in the form of a dark ball. This manœuvre is repeated again and again with great rapidity and regularity.

* Mr. G. W. Goyder, C.M.G., Surveyor-General, Adelaide.

* SMOKE PUFFS.

At Port Darwin the natives at times make a complex signal by the use of one or more sheets of bark of large size. The sheet is set on end before the fire, and by a sudden downward flap of the bark sheet the smoke is suddenly driven away sideways, then rising into the air parallel to the parent smoke. By repetitions and alternate flaps from the opposite side numerous variations are obtained by the operating signallers.

PARALLELS.

At times dark smoke-producing material is laid (by the same tribe) in the centre of a clear fire of dry fuel. The resulting dark smoke from this superimposed material is caught in the lower mouth of a tube formed of bark, the upper mouth being held outside of the rising volume of pale smoke. The dark smoke is thus made to rise outside of, but parallel with, the pale smoke of the parent fire. Balls, or balloons, or cloudlets of smoke are produced in the column of uprushing heated air in such manner as to secure a succession of five or so in sight at once. The small bodies of smoke are so formed as to rise at fairly regular intervals, either as to space or time. The time intervals may be half-minutes, or may be hours, as the signal requires. Sometimes the column is interrupted a few times only in the course of a day. Variations may also depend upon the quantity of dark smoke-producing material laid on the fire at any one time. The signaller may play a "dot" and "dash" effect on his smoke with any variation as to rapidity of "dots" or length of "dashes" his code may require.

Interruptions are variously secured. Larger or smaller quantity of material superimposed upon the fire; a rug held over the column of rising smoke to gather the smoke in a body beneath it; quick removal of the rug releasing the puff or ball for its ascent; or smothering down the smoke by quickly and thickly superimposed boughs of trees or bushes, the equally sudden removal permitting the puffs or cloudlets to rise again, or the column of dark smoke continue to rise without further interruption, as the signaller may determine.

FESTOONS OF SMOKE.

† Festoons of smoke in connection with lubra stealing are usually used by a native moving rapidly who wishes to convey a quickly passing message to his own people. A string of grass, tied together, having been made by the native as he runs (for he is generally being pursued) the festoon is hung upon the boughs of a convenient tree, and having been lighted, the signaller speeds on in a zigzag course.

* Mr. T. A. Parkhouse, Adelaide.

† Barrow Creek tribe.

Hollow trees are commonly used in Victoria, on the Darling, on the Finke, and in the Northern Territory. * Green, dark smoke-producing material is thrust into the upper part of the tube and dry fuel at the lower end. On firing, dark smoke issues from the top of the tube, and varying effects are produced at will. †At the Glen Helen Station, Northern Territory, the signal was used to indicate to wild natives the movements of the station blacks. Mr. V. L. Solomon, M.P., states that to secure a variety of signal a second separate smoke is raised a few feet from the base of the tree by Northern Territory tribes. Speaking of this system of signalling, Mr. C. Hope Harris, Survey Department, South Australia, says:—“About sunset is their favorite time for these social inquiries. The basis of such signals consists of puffs of smoke raised at various intervals, and continued for greater or lesser lengths of time, further marked by peculiarities of appearance and relation to the direction of the then prevailing wind. These effects are produced by placing the fuel in such manner as to catch the wind over the fire, heat it, and thereby cause it to ascend either in a calm vertical column of smoke, or in a spiral coil, or in fitful puffs. The sudden suppression of smoke is most remarkable, and evidently forms an important element in the practical application of the system; and, taken into consideration in connection with the readjustment of the fuel for another puff, we are led to infer that the manœuvre is the result of experience, transmitted or inherited through many generations.”

INSTANCES IN ILLUSTRATION OF THE USE OF SIGNALS BY NATIVES.

H. T. Morris, Esq., Adelaide (H.M.S. *Buffalo*, 1836), sailed through Investigator Straits, and smokes were raised first on Yorke's Peninsula, and in rapid succession at Cape Jervis, Peeralilla, O'Halloran Hill, Mount Lofty, Barossa, and on northward to the bounds of vision. The natives evidently were informing friends of the presence of strangers in their waters. Peeralilla, Hindmarsh Valley, was a beacon hill from which signal fires and smokes were exhibited.

“Mitchell's Australian Expeditions,” vol. I., pp. 128, 197, 264, 285; vol. II., pp. 241, 243, old edition, gives illustrations of use of signals.

Eyre's Explorations, vol. I., p. 146; vol. II., p. 281.

The Journals of John McDouall Stuart, 1858-1862, pp. 215, 216, refer specially to the use of smokes at Attack Creek.

Mr. W. P. Auld, of Stuart's Expedition, 1861-1862, relates that on the return journey from the Indian Ocean news of the arrival of the party at the region of the Taylor was conveyed to Mr. Levi's Mount Margaret Station, over 600 miles on the line of travel,

* V. L. Solomon, Esq., M.P., Adelaide.

† W. Thorold Grant, Esq., Adelaide.

by means of smoke signalling. The fact that the party was returning, together with the numbers of men and the horses, was known at the station six weeks prior to their arrival. Attention should be given to the fact that the incident illustrates that the natives were enabled to enumerate a much larger number than four or five—the limit usually placed to their powers of enumeration. The members of the expedition are emphatic that blacks, in their wildest state, indicate numbers up to several score quite accurately, by repeatedly opening and closing the fingers upon the palm of the hand; and, further, that they can convey such enumeration by smoke signal. Here is evidence of far greater intelligence than is usually placed to their credit. Mr. Stephen King, also a member of this expedition, confirms the truth of the above statement.

In "Aborigines of Victoria" R. Brough Smyth, quoting from "Overland Expedition," Jardine, p. 85, says of the natives of Cape York:—"Communication between the islanders and the natives of the mainland is frequent, and the rapid manner in which news is carried from tribe to tribe to great distances is astonishing." (Also p. 153, "Aborigines of Victoria.")

"The Australian Race," Edward M. Curr, vol. I., p. 93; II., p. 418. "Report of the Coast Country, &c., from Cockburn Sound to Géographie Bay, W.A., 17 to 30 Nov., 1829," Mr. Collie and Lieut. Preston, R.N.

Dr. Imlay (January, 1838), in his "Journal of a Trip to the Murray," accompanied by Mr. Hill, narrates that near the river "we saw a circular smoke arising from a wood on the adjoining height," and, hearing a low cooe from the opposite bank, they ascended an eminence and "perceived signal fires in every direction."

Messrs. Hill, Wood, Willis, and Oakden (March, 1838) made a trip northward through Cockatoo Valley to the Murray, where they saw native signal smokes and numerous natives gathered.

Mr. Stephen King, Survey Department, Adelaide, says that during the Overland Telegraph construction, 1870-71, the natives of the coast informed the natives at Leichardt's Bar, by signal smokes raised along the course of the river, of the arrival of vessels at the Roper River mouth, sixty-five miles from the camp. Both the natives and the whites drew figures of vessels with the finger in the sand in confirmation of the accuracy of the information.

Mr. C. G. Carruthers, explorer, states that signal smokes, both pale and dark, are in constant use in Central Australia, verging on the boundary line of Western and South Australia, and in the Macdonnell and Musgrave Ranges country. He describes funnel-shaped channels, scooped out in the earth surface, leading from outside the fire area to underneath the dry fuel of the fire, to provide a free supply of air to the fire, and so aid in the progress upward of the signal. Green material is laid on the fire to produce dark smoke. The native signaller can, if desired, so construct

and manipulate his signal as to make it rise an appreciable and sufficient height against the wind to secure his object. Some signals owe their special significance to their peculiar rush against the wind.

W. G. Stietton, Esq., special magistrate, Borrooloola, N.T., says, "Their (the aborigines) principal means of communication is by putting up smoke."

Ernest Giles, "Travels in Central Australia, 1872 to 1874, p. 13 and p. 176, "Signal fires were lighted immediately in order to collect the whole tribe."

Mr. L. A. Wells, explorer and surveyor, attached to the Elder Expedition, 1890, describes the use of smoke signals at Mount Squires, W.A., when a signal was observed at seventy miles distance by the aid of a glass (the signal being a short-lived small one), and their use also on the Queensland western boundary.

Mr. S. W. Herbert, Survey Department, S.A., illustrates these signals by the case of s.s. *Omeo*, 1870-1871. Her passing Cape Yorke was noted and signalled from an adjacent island, and conveyed by the natives' signal line of smokes to Port Darwin, so that residents there were aware of her approach two days prior to her arrival.

Mr. Frank Naische confirms the statement, saying that such announcement of movements of vessels was quite usual there.

*When the late Messrs. Cowan and Bullimore were killed in the railway accident of July 21st, 1890, news of the event reached Charlotte Waters Telegraph Station the following day. Natives there, learning the facts, conveyed the tidings that same evening to Mr. Cowan's Crown Point Station, fifty-six miles distant, by smoke signal, and it was known by the station blacks that evening, though treated by the manager and the whites as an idle or confused report. About 1 p.m. of the next day confirmation of the news reached the manager, Mr. T. G. Magarey, in writing, sent from the telegraph station. Meanwhile the news had been travelling on, and was known at the Johannesburg Aboriginal Mission Station, 265 miles north-west from Crown Point, very early in the morning of Wednesday to the whites there, having been conveyed by smoke signal. A Crown Point Station hand (formerly on Lake Hawden Run, near Robe) was at the mission station, and on hearing the news and thinking his own manager was dead, rode homewards, eighty-five miles, to Mr. Parke's station. He there learned that Mr. Cowan, owner of Crown Point, was dead, and returned to the Johannesburg Station to complete his errand. As the incident above narrated indicates marvellous powers of message sending by smoke signalling on the part of the natives, it may be well to glance at how, conceivably, it could be accomplished. There are many signals in every day use in station life in Central Australia. The native station hands there use smoke signals as a matter of daily convenience.

* T. G. Magarey, formerly manager of late Jas. Cowan's Crown Point Station, N.T.

The movements of the manager, of the police, of the ration-cart, of natives themselves, of mobs of cattle, horses, and sheep, are constantly indicated. The message in question could, conceivably, be smoke-flagged by the use of seven code words, used in the native fashion, terms in constant use in the region, *e.g.* :—1. "Almerta-boss" (meaning headman, master, owner); 2, "Crown Point" (localities have code-signals); 3, "With comrade" (also an idea in constant use); 4, "In wheelbarrow" (every wheeled vehicle is termed a wheelbarrow in Central Australia); 5, "Nanto" (horse); 6, "all swallowed up" (*i.e.*, all killed outright); 7. "Dichika" (devil. *i.e.*, railway engine) So reading:—The Almerta boss belonging to Crown Point, with a comrade in a buggy, with a horse, are killed by a railway engine. Not one of these terms is unusual there. The novelty of the idea of such action on the part of the natives is the chief difficulty in the way of the acceptance of the fact by their white critics. Amongst white dwellers in those regions it is no novelty. It must be remembered that such long distance messages are repeated again and again, as the distance to be traversed requires. The 321 miles or so, *e.g.*, of the present illustration might require a dozen or fifteen repetitions. Further illustrations might be abundantly multiplied, but space will not permit; sufficient has been presented to show the marvellous skill of the aborigine as a signaller.

As to any practical use which, in the interests of civilisation may be made of the natives' smoke signals:—Australia, owing to its physical characteristics, must for many years to come, as to its central regions, be occupied by a sparse, scattered population. Travellers, bushmen, and carriers in the regions where waters are few and far apart will always have use for a system of smoke signals, by which to convey messages across the long distances of the remote interior, where other means is not available. For example, let the ordinary dark column of smoke be selected as the code signal for the bush, indicating "distress." If made an "interrupted" signal it would be the more efficient. In native fashion let the same signal-form be used as the "reply smoke." A man, for instance, is lost in the bush, is ill, or is perishing from thirst, and is miles away from any station or from help. Let him now raise from the material at his hand the interrupted dark smoke signal, and keep it showing until replied to and he is rescued, and let him stay by his smoke. Ere long his gladdened eyes will sight the welcome "reply" smoke rising, and saying to him, "Your distress-smoke is seen and help will reach you soon." How different the position of this "done-up" bushman from that of so many distressed men who to-day perish miserably and alone, only because these cannot say, as the intelligent aborigine similarly placed does say—"One fellow sit down ill; send a man." Making use of native methods, our bushmen and police might gainfully adopt a few simple code signals for use in the bush, just as the

half-masted flag at sea and liferopes and lifebuoys on our seaboard are devoted to rescue and life-saving. Let the code smokes be regarded as sacred for such rescue work, and many an otherwise "unknown," instead of being "found dead," will live to bless the aborigine for his graceful and useful smoke signals. [N.B.—On the day that this paper was read (September 28th, 1893) news reached Adelaide that a man had perished miserably from want of water on the Overland Telegraph line near Tennant's Creek, after having vainly tried to cut the wire to attract attention.]

As the visitor to the great "Mammoth Cave" of Kentucky is shown branch after branch of that cavern by his darkie guide, all of which he must pass by and leave unexplored, so, in gathering these spoils from the customs and folk-lore of our dusky fellow-countrymen, I have had to leave on one side fire-signals, messengers, and message-sticks, with other bypaths, all of which would tempt one to turn aside from the present task, self assigned. As it is, the boundary line only has been crossed. The whole wide field of these smoke signals, their use and code meanings, still lies open for the future explorer. As the brave indomitable Eyre traversed the coastline of Australia from Port Lincoln to the "Sound," so has this paper skirted only the shores of this subject; and it remains for some Stuart, or Giles, or Forrest to search through the great unknown, and bring back new facts concerning the Smoke Signals of our Australian Aborigines.



2.—ON THE NEED FOR MORE EFFICIENT CO-OPERATION AMONG ANTHROPOLOGISTS OVER THE INDIAN, POLYNESIAN, AND AUSTRALIAN REGION.

By S. E. PEAL, F.R.G.S.

(COMMUNICATED BY PROFESSOR LIVERSIDGE, F.R.S.)

[This letter contains a brief summary of a paper published elsewhere, but read before the Association.]

Sydney, September 10th, 1893.

Dear Professor Liversidge—I am sorry I missed you, and now write to say that on my return to Asam I hope to work at the development of tribes and clans. The history of such are to be obtained, particularly among our head-hunting Naga.

There are, firstly, huge groups, such as the Naga, Miri, Lushai, Kuki, Mani-puri, Chins, Mikir, &c., all with strong physical and linguistic affinities.

Secondly, each of these in turn is cut up into minor clans, as a rule endogamic and with more marked resemblance, having often

traditions of relationship. One of these groups of the latter kind I know a little about. It consists of forty-six villages, say, average 1,000 souls each, and they now constitute about ten distinct sub-tribes, often at war with one another, and taking each others' heads. All are descended from a place called "Changnu," and its earlier off-shoots. The lines of their tribal development, if plotted on a map, show as radial lines, and some go back for twenty generations. There is a large amount of good history ready for any investigator; quite 90 per cent. will be lost, I believe. In some tribes government is quite democratic; in others (near me) it is by hereditary chiefs, and nearly despotic.

Very few men on our side realise the extraordinary intricacy of the Australian clan and marriage systems, and few on your side (here) seem to be aware that probably the clue rests with us in Eastern Bengal, where the growth of tribes into tribelets is now going on before our eyes actively, and where there is the greatest elasticity seen in action among endogamic and semi-exogamic tribes and races of strongly communal tendencies still in many ways.

It is a pity that the terms marriage, husband, and wife have been so misused by writers on Australian customs. As a rule "communal marriage" is a misnomer.

Marriage is really the *public ceremony* intended as proof that a particular female has become the property sexually of one male, and is thus cut off from the public or commune. Our Asamese betrothal is thus "Bhuja pelaisi," *i.e.*, "Knowledge thrown about," a giving the bond publicly.

The two terms "communal" and "marriage" are really mutually antagonistic and antithetical.

In *re* husband and wife again: It is often said that men are the husbands of women of a class and women the wives of all men of another class, yet no ceremony is performed. This "pirauru" is simply right of paramour liberty of sexual intercourse derived from a communal stage. The terms husband and wife imply to us much more, *i.e.*, prolonged cohabitation as well as segregation. The tribal horror of "incest" is marrying and isolating a public girl (a tribal sister); it is a communal sin, and this is demonstrated by the fact that among all blood relations there is really sexual liberty till marriage.

The gross licentiousness and public orgies, such as the "wira-jinka," where all the men and boys have sexual intercourse with females "no matter what their relationship," is proof of it. It is tribal "incest" to "marry" a communal girl, and this term is misleading in consequence. The blood means the tribe. You will find by "Heth's Marriage of Near Kin" that the injurious effects of close intermarrying is a myth, and hence cannot be the basis of the Australian horror of blood alliances. That is the relic of a communal sin.

Yours, &c.,

S. E. PEAL.

3.—THE HABITS, CUSTOMS, AND CEREMONIES OF THE ABORIGINALS ON THE DIAMENTINA, HERBERT, AND ELEANOR RIVERS, IN EAST CENTRAL AUSTRALIA.

By FRANCIS H. WELLS, of the South Australian Police Department.

Tribes.—The natives of the localities named belong to the Andrawilla tribe, and occupy a block of country about ninety by ninety miles. This chief tribe is sub-divided into smaller tribes or clans, viz.:—Andrawilla, Kuntapunchinna, Dickeri, Kyratonka, Kertie-terrie, Yumalla, Kerra, Dipracoolie, Tunbulla, Koringurra, Kalkaparichinna, Mundowalla, Tippaminkinna, and Dampaminnie; these tribal names being taken from the names of various waterholes in the locality inhabited by the tribe, such as Andrawilla, Kyratonka, &c. Both men and women are tattooed on the breast, arms; and legs, different patterns being adopted by each tribe, such as emu foot on the Dickeri tribe, and iguana tail on the Andrawilla tribe. This operation is performed at the age of twelve years.

Individuals are named after animals, birds, plants, fish, or fire. A native so named after an animal regards it as sacred, refusing to kill or eat it, believing that if he did so he would become very ill (wi-wi) and die.

They have no ceremony corresponding to baptism or appointing godfathers or godmothers; but if the mother of a child should be called away for a few hours, and during her absence the child should be suckled by another woman of the tribe, then this woman is for the future considered a "picanniny" mother, and her husband a "picanniny" father to the child.

When twins are born, and one should happen to be a male child, he is killed. Half-caste children of either sex, when born, are always killed and occasionally eaten by the tribe.

When a boy is sixteen years of age he is circumcised. The operation is performed at sunrise by six old men, with pieces of sharp flint. A girdle of woman's hair about 20ft. in length is then very tightly wound around the boy's waist, the ends hanging down in front and forming a tassel. At about the age of twenty-five years a further operation is performed, the urethra being split open by cutting with a sharp flint; but this custom is not observed in all cases. The noses of both males and females are bored with a piece of bone and their two front teeth knocked out when they are children. Three old women perform this operation, using a pointed stick and stone.

Marriage.—A man guilty of fornication with a woman of his own tribe is liable to be killed, and the woman is branded all over the back and posterior. When a man wants a wife he must give a sister to the tribe from whom he wishes to obtain his spouse. He

lives with his wife's tribe for three moons (months), and then takes her to his own tribe. The marriage ceremony is as follows:—The parents of the bride have a ball made of copi (gypsum), and the parents of the bridegroom have one made of red ochre. The red ochre ball is given to the bride and the gypsum ball to the bridegroom. If the bride cannot agree with her husband, she buries her ball in the sand, and *vice versá*; and if she wants to leave her husband altogether, she smashes the ball in pieces and throws the pieces into the air. The husband then gathers her belongings and burns them, and *vice versá*. A man is allowed to have two wives, and when away from the tribe for any time and not taking his wife, often hands her over to an unmarried man (pera), who can enjoy the privileges of the absent husband. If the husband dies, the woman can marry again.

The left foot of a woman is considered unclean.

Disease and Death.—All diseases are supposed to be caused by the bone of a dead blackfellow being pointed at the sick person. If a man or woman dies the cause of death is always put down to the pointing of the bone. If a blackfellow of the Dipracoolie tribe wished to be revenged on a blackfellow of the Andrawilla tribe he would point a bone (taken from the arm of a dead blackfellow) in the direction of Andrawilla and then take the bone to a waterhole and stick it in the mud. The blackfellow who is supposed to have had the bone "pointed" at him dies from fright. A body of twelve armed men (pinya-pinyas) of the Andrawilla tribe are told off to kill the blackfellow who pointed the bone. He is invited out to a hunt by his own tribe; the pinya-pinyas are hidden; his friends fall off one by one, and then the pinya-pinyas jump out of their hiding-places, fall upon him, kill, and bury him.

The following incident occurred at Andrawilla two years ago:—A blackfellow died at Kuntapunchinna, and it was supposed by his friends that a bone had been pointed at him. A blackfellow who came from Coongye, on the River Cooper, was on his way to Sandringham, in Queensland, for the purpose of obtaining pituri (native tobacco). He was invited to stop for the night by the Andrawilla tribe, as he was suspected of having pointed the bone that caused the death of the blackfellow at Kuntapunchinna. During the night a body of pinya-pinyas came from that tribe and killed and buried him.

Syphilitic diseases are treated by the sufferer being taken to the edge of a waterhole and buried in the mud up to the navel for fourteen days, during which time he is fed, and a shelter is erected to protect him from the weather. At the expiration of that time he is dug out, and it is said generally completely cured.

Burial.—When a native is dying all the members of the tribe sit in a circle and sing a death dirge, the body of the dying person being kept warm by being covered, all except the head, with hot sand taken from underneath a fire. Upon death occurring a grave

is dug about 6ft. in depth. Cane grass is placed on the bottom, and the naked body is lowered down. Cane grass is then placed over the body, and the grave finally filled up and rammed down with earth mixed with cut up cane grass. The body is laid at full length in the grave, and pointing north and south. Burials always take place at sunrise; and after a death the tribe leave the camp for three days and nights, keeping up during that time a continuous howling. The relatives of the deceased enter into mourning by covering themselves from head to foot with burnt gypsum, similar to pipeclay. Five small circular holes about 2ft. in depth are excavated by means of a boomerang round the wurley of the deceased, and the wurley is then burnt. The bones of the dead are never disturbed or touched, except for the purpose of obtaining an arm-bone to point at an enemy. The murder of a native is always avenged by one of the deceased's relatives.

Wurleys.—The wurleys at a permanent camp are dome-shaped circular erections built of logs, cane grass, and mud. In the cold weather fires are kept constantly burning inside. During the summer months the natives keep inside their wurleys in the daytime, thus avoiding the intense heat, but sleep outside at night. At a temporary camp a breakwind of boughs is erected, and at night they sleep in hot sand, an excavation being made in the sand over which a fire has been burning in the daytime.

Fire.—Fire is produced by a hole being bored in a piece of native flax or rotten wood, and fine sand placed in it; a piece of hard wood is twirled in the hole between the two hands, and in a few minutes the friction produces fire. Fires are only kept alight as long as required. Fire is supposed to have the power of speech, telling them what other blackfellows are doing a long way off.

Food.—With the exception of the animal they are named after and pork, anything in the way of food is eaten. Gum picked from bean trees (*Bauhinia sp.*); yowas, somewhat like a pea, found in the sandhills and eaten green; munyeroo (similar to an *Oxalis*), eaten green (probably *Claytonia bulonensis*); pigweed seeds ground between two flat stones, and the flour mixed with water and made into a paste; nardoo seeds (*Marsilia quadrifolia*) ground, mixed with fish fat and baked in the hot ashes; mussels, mudlacoopa (fish), multa multa (fish), iguanas, rats, carpet snakes, dingo pups, wakarees (a grub found in trees), ducks, pelicans, divers, and golahs. These last are simply covered with hot ashes and baked whole. Crows, hawks, black cockatoos, or venomous snakes (coolas) are not eaten. Young blackfellows are prohibited from eating emu and swan eggs, it being supposed that this diet would make them greyheaded. They are, to a certain extent, cannibals, children being sometimes eaten, and if a strong black-fellow should die his body is suspended over a fire and the fat that exudes and drops is caught in a wooden vessel (koolaman); this fat is rubbed over their bodies. The sinews of the dead man are then

eaten to make them strong. A corroboree (dance) is held before the feast, and when all is over the koolaman is burnt.

Pituri, or native tobacco, is obtained from Sandringham, in Queensland, and is chewed by both men and women. It is prepared by burning the leaves of the gidyea bush, the ashes being carefully gathered up and mixed with the pituri, which has been previously chewed. The mixture is then passed from one to the other.

Fish are caught by means of a large net, about 20ft. by 10ft., made of native flax. At each end is fastened a long stick. Two blackfellows take the net—one at each end—and, with the net stretched out to its full length, swim quietly and slowly across a waterhole, invariably catching a few fish. When hunting or fishing words are never spoken, all communication with one another being by signs, thus preventing the game from being frightened or disturbed. In order to be a lucky hunter a native will scarify himself across the breast with a piece of sharp bone, and after a successful day's hunting or fishing a corroboree will be held. The animals or fish are cooked without disembowelling, being placed in the ashes and baked whole. The blackfellows always eat first, the women afterwards.

War.—Before a war is declared between two tribes a big corroboree is held, the natives decorating themselves, covering their bodies with alternate rings of red ochre and burnt gypsum. In actual war quarter is never given or accepted.

Government.—There is no form of Government. The old men of the tribe possess a large amount of power over the younger members from the fact that they perform all the important tribal ceremonies. The old men are supposed to be able to make rain and inflict and cure diseases, and drive away devils (koochoo.) If a blackfellow is ill and suffering from a disease one of the old men takes a mouthful of water and then blows it out of his mouth on to the diseased part of the sick man. The old man then sucks the place, but, before doing so, secretly puts a piece of red ochre into his mouth; he then spits out a reddish fluid somewhat resembling blood. In order to make rain the old men cut themselves on the ears and both sides of the face. Rain is also made by the following ceremony:—Twelve old men sit down at a small waterhole and make a large copi ball about 10lbs. in weight. The ball is put into the waterhole and the twelve men return to the camp. Then one by one they go and have a look at the ball to see if it is dissolved. When it has dissolved it is bound to rain.

During the winter months they amuse themselves by spinning round balls made of copi (gypsum) on flat pieces of wood.

Calculation.—They can only count up to twenty. Each hand stands for five, the hands and feet combined for twenty. Any further number is signified by signs meaning a mob or many. The age of children is reckoned by so many moons.

A big corroboree is held at each full moon. When the sun goes down the old man goes to sleep, and the old woman (the moon) and picaninnies (stars) walk about.

Religion.—They have a belief that human beings possess souls. When a blackfellow dies it is supposed that the soul leaves his body by way of the mouth, and enters the body of a whitefellow, also passing in through the mouth. The whitefellow who thus becomes the domicile of the dying black man's soul is supposed to be born at the time of death of the blackfellow.

The devil (koochoo) is also acknowledged. He lives in the west. His skin is of a red color, and he has four eyes, two in front and two at the back of his head. He comes to steal away the young gins. He is exorcised and driven away by cries and shrieks and the noise produced by knocking boomerangs together. Dreams are also believed in, but an explanation as to the cause of them is unknown. The names of the dead are never mentioned; it is thought that the deceased would never rest peacefully should his name be spoken.

Dancing is indulged in, being very similar in style to the antics of the native companion. A circle is formed by the men, who dance until thoroughly exhausted. The women keep in the background, and an old man keeps time by knocking two boomerangs together. The tallest and best-looking of the men acts as leader of the dance.

Corroborees for various purposes are held, such as for making rain, fish, or rats, but the details are too disgusting to be described.

Weapons.—Boomerang, nulla nulla, spear, and shield.

Utensils.—Koolaman (bowl for holding water); nets made of native flax, for fishing and snaring ducks; stone knife; stone tomahawk; two flat stones for crushing nardoo and pigweed seeds.

Blackfellows' Names.—Kooripipinna, Appa-kulta, Toondroowonko-innā, Wadoo-woka, Watti-wattina, Tring-alli, Watti-katannā, Ooroo-charoo.

Gins' Names.—Paroo-moogunna, after a fish; Nooyoo-nackaroo, after a fire; Akka-willi-likka, after a fire; Naru-wa, after a fire; Wilyeroroo-mun-nung-arrie, after wind; Wumma, after a snake; Kal-li-irri, after a fire; Wooti-inna, after a snake; Yarra-guninnā, after a snake.

DIALECT.

English.	Native.	English.	Native.
Ants	Merri-kā	Bone	Wal-poo
Arms	Bul-yā	Boy	Wee-i
Anus	Milyerrie	Blood	Koo-marri
Back	Moo-dā	Beard	Mun-kā
Bag	Yak-kootā	Breasts	Mum-mā
Bark of tree .	Yet-an-na	Bread	Mulya-mi
Big	Tip-pee	Brother	Noo-yoo
Bite	Mut-tānnā	Blowing	Pool-ko-annā

DIALECT—*continued.*

English.	Native.	English.	Native.
Billycan	Warra-chuna	Fat	Wom-mā
Bottle	Koo-poola	Fur	Mul-ta
Boot	Tidna-boota	Fire	Too-roo
Calf	Wirri-pā	Fly	Moon-choo
Cane grass ..	Bree-ta	Father	Mul-pi
Calves of legs	Pur-rita	Frown	Boo-choo
Cutting	Dum-an-nā	Four	Wi-tā
Cold	Krip-pā	Feathers	Kurl-yā
Crying	Indra-na	Gammon	Wong-koo
Cheeks	Nal-ya	Grass	Win-thee
Chest	Pitta-witta	Grub	Mool-yi
Chin	Munka-chedda	Girl	Queei
Copi (gypsum)	Wal-yoo	Go on	Koppa-ri
Come back ..	Tik-annā	Give	Munki-ammi
Come along ..	Kowi	Go back	Tik-annā
Cow	Ammā-milki	Gun	Mukittā
Crayfish	Koon-tā	Go away	Euka-an-ri
Crane	Poo-ral-koo	Golah	Killān killi
Crow	Koo-kunta	Hair	Moo-doo
Clean	Warroo-koo	Hat	Oo-too-maner- rie
Deaf	Ya-ree	Hit	Tun-dera-nā
Dark	Meel-ya-roo	Heavy	Muckoo-munda
Dog	Teeri-tā	Hungry	Moo-an-oo
Dead	Pul-tā	Hole	Koo-doo
Dig	Tap-poo-lee	Hold on	Karrā
Diver (bird)..	Woochoo-buk- anni	Hand	Murrā
Devil	Koo-choo	Heel	Tidna
Dress	Broo-kā	Head	Noo-doo-tun- derra
Dust	Woo-too-roo	Heart	Wal-derrā
Damper	Wai-mal-ya	Hole thro' nose	Moodla-wilpā
Duck	Pi-yā	Handcuffs ..	Warika-mun- drinni
Dirty	Warroo	Head dress ..	Multārrā
Eyes	Mil-ki	How many ..	Tee-rankoo
Elbow	Mumpo-kaddi	Iguana	Wump-pikka
Eyebrows ..	Bil-pā	I don't know..	A-nā-goo
Eyelashes ..	Milki-wirrie	I kill you	Pre-tanā
Emu	Warra-katchie	Intestines ..	Murrangarra
Excreta	Koona-oonā	Kangaroo	Choo-koo-roo
Eucalyptus ..	Bulka-kulla	Knees	Bun-chā
Earth	Purra-ka	Knife	Ni-pā
Fish	Warrie	Kissing	Mun-chin-nā
Flame	Yap-pinna	Kicking	Tukka-manna
Forehead ...	Mool-loo	Kill	Tunderra-anna
Feet	Tid-na		
Fingers	Murrā		

DIALECT—*continued.*

English.	Native.	English.	Native.
Licking	Tunya-anna	Sneezing	Kootoo kootoo-gudda
Lazy	Mumma-anna	Stone	Mud-dā
Lake	Wurra-li	Sand	Dar-koo
Long time ..	Minna-minna	Sandhills	Dar-koo
Leaves	Thalpoo	Salt	That-too
Lips	Pim-mā	Sleep	Pur-rinna
Lizard	Kad-ni	Stomach	Toon-droo
Louse	Pir-di	Sore	Min-kie
Long nose ..	Mood-la	String	Urip-ā
Lightning ..	Mil-yar-roo	Scratching ..	Mirrā-chuntā
Liver	Kull-yoo	Sun	Kul-kā
Look out	Nil-kan-nā	Sundown	Ditchi-wirrina
Long way ..	Warrā-tā	Spear	Wadna-quin
Laugh	Kunkā-annā	Smoke	Tuppa-inna
Man	Kalkā-arroo	Stick	Prit-ta
Me	Mun-yi	Shadow	Mil-poo-ooroo
Mouth	Pim-nā	Sky	Mil-ya-oorroo
Moon	Perā	Shoulders ..	Winka-arrie
Mosquito	Koon-ti	Snake	Tip-pā
Mother	Mundri	“venemous	Tundri-prilla
Mob	Wit-tā	Spitting	Kuntha-urnā
Moths	Mi-attā	Sit down	Mammā-na
Mopoke	Munkā-noo	Stand up	Tulkallā-tundā
Mussel	Koo-ri	Sick	Wi-wi
Neck	Oon-koo	Snoring	Mundoo-rainā
Nails	Nirri	Shield	Murrā-numma
Navel	Pin-tā	Skin	Kul-tā
Nose	Mood-lā	Shame	Munthā-unnoo
Nostril	Moodlā-wirripā	Sweat	Kung-oo
No	Wo-bā	Spider	Mutta-nā
No good	Mun-nā	Small	Koo poo-ta
One	Oon-wārrā	Stink	Toon-kā
Old man	Kulkā-arroo	Suck	Tup-pannā
Old woman ..	Widlā-prinnā	Swimming ..	Turra-gunna
Parrot	Kundrā-ungoo	Sunrise	Moo-yoo-untā
Penis	Oon-too	Scalp	Wil-kā
Pigeon	Wappāroo	Two	Par-koo-oonā
Pelican	Tum-pung-ārrā	Three	Parkoo - oona - oona
Pouch (pelican)	War-roora	Teeth	Munna-deerie
Quart pot....	Walpa-ittā	Thighs	Wil-yi-ri
Run	Pool-kannā	Teats	Mummā-brinnā
Rat	Mi-arroo	Testicles	Dam-poo
Red ochre ..	Kal-koo	Tickling	Kicherie poo-doo poodoo
Rump	U-rā		
Sister	Kar-koo		

DIALECT—*continued.*

English.	Native.	English.	Native.
Toes	Tidna-nulki	Veins	U-ree
Tail	Kid-ni	Water	Nap-pā
Thunder	Mik-arrie	Wood	Thal-poo
Thirsty	Won-koola	Wrist	Oon-nā
Tattoo mark .	Mundri	Whistle ...	Wil-prinnā
Throw	Warrinā	Whirlwind ..	Wom-meria
Tall	Warrā li	Womb	Kulyi-erra
Tomahawk ..	Kommi-yakoo	Windpipe ..	Ulkoo-anna
You	In-ni	Wet	Kung-oo
You walk ..	Wop-pinna	Woman (mar- ried)	Willa-prinnā
Yawn	Yuk-ki-yi	White	Wil-ye-u
Yes, I know..	Pe-pe	Whip	Takoo-ippa
Uncle	Kuk-kā		
Vagina	Milyi		



4.—THE STONE IMPLEMENTS OF THE ABORIGINAL TRIBES OF THE SEABOARD OF SOUTH AUSTRALIA.

By WALTER HOWCHIN, F.G.S.

(BRIEF EXTRACT.)

Whilst implements of wood and rude textile manufactures of the Australian aborigines have been carefully noted and frequently described, much less attention has been devoted to the stone implements of the natives. The paper gave the results of twelve years' gatherings of the stone implements of the extinct tribes that occupied the seaboard extending from Adelaide to Port MacDonnell. About a thousand objects were exhibited illustrative of the subject, consisting of—(1) stone points; (2) flakes (knives), in seven varieties of single-edged, ridged, flat and polygonal, lanceolate, broad, serrated, and trimmed; (3) spearheads of a type which seem to be restricted to a narrow coastal belt; (4) chisels; (5) gouges; (6) awls; (7) scrapers, divided into eleven distinct varieties; (8) hammers; (9) anvils; (10) fabricators; (11) cores. A comparison was made between the Australian stone implements and the prehistoric remains of Europe, India, and South Africa, showing the essential similarity of type throughout, but with local differences.

5.—NOTES ON SOUTH AUSTRALIAN PHYSIQUE AND MORTALITY.

By J. H. D. DAVIDSON.

(WITHDRAWN.)



6.—THE SURVIVAL OF THE UNFITTEST.

By H. K. RUSDEN.

(ABSTRACT.)

By natural selection organisms of all kinds possessing strength, fleetness, or equivalent advantages, live and procreate; while others, without them, cannot survive. By removal thus of, say, 10 per cent. of the most incompetent, the average viability is raised half as much, or 5 per cent. But promiscuous parentage tends to mediocrity. The strong, swift, and hardy survive and propagate; the weak, slow, and delicate die. Thus the fittest survive. The strong devour the weak, the swift the slow, and savage man kills all. Some he tames, as useful to him. He artificially selects and carefully cultivates the best only, excluding the less useful from parentage, and so improves the progeny more than 90 per cent. in one generation. Darwin showed how breeders do this persistently and wonderfully. But civilised man, though thus improving domestic animals, does stupidly just the contrary with his own kind, which he not only does not improve, but persistently degrades. He nurses and cultivates the criminal, the lunatic, the defective, and even the incompetent and the unthrifty. The medical profession is proud of preserving those whom nature would exterminate, and never wisely selects suitable mates. Experience has proved that mankind is as improvable as domestic animals. Lycurgus selected parents, and forbade the rearing of defective children; and Draco enforced a uniform death penalty for crime. To this has been ascribed the great superiority of the Greeks for many generations. An African tribe sold all its defective people as slaves, and Winwood Reade says he never saw finer models. So the Brahmin caste and Society Island chiefs produce splendid types. Persistent degradation tends to extinction, which should be averted and reversed. Improved choice of mates or parents must now be left to public opinion, which requires enlightening and cultivating. Fortunately many women are alive to this; but the young should be better instructed. The only practicable artificial selection is the wiser disposal of those who fall into the hands of the State as criminals, lunatics, &c. If they were consistently

removed, the effect would be immense. They select themselves for removal; but we now renovate, cultivate, and stupidly liberate them again and again, to victimise society and degrade posterity. Mr. Darwin wrote to me that he had long thought that habitual criminals should be confined for life, but that he had not, until reading my views, recognised the importance of extinguishing the breed. But confinement for life is too barbarous. Humanity demands that punishment, being a failure, should be discarded. Society owes protection to good citizens, and should, if possible, anticipate first offences. It cannot anticipate the first, but it can and ought to anticipate the second, of which now it is largely guilty. Human life is worthless to society if not useful, but if mischievous it should be forfeited. And it is worthless—a loss—to the criminal, not being happy. The lives of criminals, lunatics, and idiots are not only useless, but painful to them, a mischief to society, and far worse to posterity. The humane course is to narcotise them on their first conviction. Ten years of this system would go far to abolish crime, if not lunacy, and would rapidly raise the average of morality and intelligence of the human race.



7.—NOTES ON THE OMEO AND MONARO TRIBES.

By R. HELMS.

(WITHDRAWN.)



8.—A WILD TRIBE OF NATIVES NEAR POPILTAH, WENTWORTH, NEW SOUTH WALES.

By A. F. CUDMORE.

(COMMUNICATED BY T. GILL.)

For some years past paragraphs have appeared in the public press stating that a wild tribe of aborigines existed in the mallee scrub contiguous to the boundary line between New South Wales and South Australia, but no reliable information could be obtained on the matter. Eventually, Mr. A. F. Cudmore, of Popiltah Station, succeeded in bringing the whole tribe into his station. His communication on the subject, dated September 14th, 1893, is as follows:—

"It appears that, about thirty years ago, 'Nonnia' (who is now about sixty years of age), for some reason not rightly known, bolted from Popiltah Lake with one or two lubras, and hid himself in the dense tract of mallee which covers the country for about 600 square miles along the South Australian and New South Wales boundary, from about the thirtieth to the eighty-first milepost. Here he has carefully concealed himself from the whites and blacks (being particularly afraid of the latter), living on kangaroo and whatever he could get hold of, and obtained water from the roots of the red mallee and needle or waterbush.

"During this thirty years in the wilderness the old gentleman has raised quite a little family around him, and is now the proud father and grandfather of about twenty-eight men, women, and children, over all of whom he reigns supreme, and his word is law. These blacks have remained constantly in this wretched mallee wilderness the whole time, wandering from place to place in search of food, and living principally upon black scrub kangaroos, which they sneak upon and spear. When surprised by the tame blacks they had several dogs with them, but only three came in with them; they are dingoes which they caught when young, and tamed. Their wurleys or gunyahs are very small and low, made in the usual way by piling mallee boughs together and thatching them on the outside with porcupine or spinifex. They cook all their food by roasting it in the hot ashes in a hole in the ground. Fire they produce in the old way of rubbing two sticks together: and when once they got a light, carried a firestick with them for several days from place to place. Their only weapons are mallee spears with barbed points, and their clothing a kangaroo skin with the fur side out, thrown across the shoulder and secured with kangaroo sinews. I did not notice any cuts or tattoo marks on any of their bodies, such as the tame blacks often have on the back and shoulders; and, with the exception of the old man, who is very thin, all the others seem very well developed, and the young men are very swift runners. None of them smoke roots or anything of the kind, consequently all show splendid white teeth.

"It is almost impossible to get any information out of them, and their language seems to be slightly different to the river blacks, and their captors often have considerable difficulty in making them understand, although Nonnia originally must have known their lingo. Since the country round the Scotia blocks has been improved and tanks sunk these blacks have been known to come in to the water, fill their waterbags (which are made out of skins of kangaroos' legs), and then clear off again. The tame blacks tell me they will not eat rabbits, but are very fond of cats and white ants (or ants' eggs); these latter they are very expert at getting, and use a 'koolaman,' or sheet of bark about 2ft. long and 6in. or 8in. wide as a sort of sieve for shaking the ants out of the earth; they then slightly roast them by placing the koolaman

on hot ashes. When I visited the camp after these blacks were brought in, they appeared very frightened and ran about like a number of fowls, and peered at us from behind trees and brush-wood; the women and children all ran into the wurley and huddled together so that only their heads could be seen. However, I got the half-caste, who can speak their language a little, to fetch old Nonnia out to us, and when the others saw we did him no harm they seemed to be less afraid, and all came up to me when I beckoned to them. They were particularly interested in my clothes, and especially so with my watch, the works of which I showed them. I saw two young babies slung on their mothers' backs, and a couple of little boys about six or eight years of age. The difficulty now presenting itself is what is to be done with them. I understand the New South Wales Government have given instructions for them to be let go, but I hardly think there is much compulsion about their staying in the camp now; and it would be wiser to get them to settle in on the water, where they might be made some use of as rabbiters; and, no doubt, the young men would make expert horsemen with very little practice. On the other hand, if allowed to stray back to their old haunts, and being half civilised, they may become a nuisance. At present there are three or four tame blacks camped with them, and every day the young men are taken out hunting to provide food for the camp; the idea was to get them used to seeing the whites and gradually work them into the river. I suppose when they reach the grog shanty their education will be completed. It is to be hoped they will soon be educated up to a decided taste for 'bunny.' They will not eat bread, or use tea and sugar. Old Nonnia was induced to eat a little sugar, but it made him sick. I have got from the New South Wales Government fourteen blankets for them. I have also sent them some clothes and a few trinkets."

Section G.

ECONOMIC SCIENCE AND AGRICULTURE.

1.—DEFORESTATION IN SOUTH AUSTRALIA: ITS CAUSES AND PROBABLE RESULTS.

By W. GILL, F.L.S., F.R.H.S., Conservator of Forests.

The subject of deforestation is one fraught with the most momentous issues in any country, and imperatively demands the serious attention of all who have the welfare of the general community truly at heart. To those superficial minds which think that they can settle the whole matter at once, in an off-hand manner, without being at the trouble to consult the evidence, any consideration which may be given to a question of this kind may seem out of place; and all who are determined to obtain present temporary advantage and profit from forest destruction, utterly regardless of all future considerations as to consequences, will probably resent it; but to the earnest student of Nature who seeks to comprehend her problems, and to decipher and give heed to her warnings, the subject now referred to will present matter enough for very grave reflections on the amount of mischief that can be effected—some of it quite irreparable—in an exceedingly brief space by man's meddlesome and reckless interference with the all-wise arrangements of the Creator. The object of this paper is not to attempt to deal exhaustively with so extensive a subject, but merely to glance rapidly at some of its more important phases; to refer to a few of the incontrovertible facts that attest, beyond all power of contradiction, the ruin that has followed in the wake of reckless deforestation in other lands; and to point out that unmistakable indications already present themselves that some of the evils referred to have even now begun their ruthless work in this colony of South Australia. Prominent among the causes of deforestation in this colony may be placed the following:—

- 1st. The felling of trees for timber or fuel.
- 2nd. The grazing of forest land by stock, with its attendant evils of overstocking, and bush fires, "ring-barking," and "sheoaking."
- 3rd. The clearing of forest land for cultivation.

There are other causes which occasionally contribute their quota towards forest devastation, but, inasmuch as they have not been as yet satisfactorily accounted for, it is profitless on this occasion to

ventilate merely theoretical opinions or hazard random conclusions; those already alluded to, being the result of human action, are largely preventible, or capable, at any rate, of modification. It is with them, therefore, our business lies; the others, originating probably from natural peculiarities of soil or phenomena of climate, may wisely be relegated for the future consideration of those having the necessary leisure to deal with them.

The felling of trees for their timber for various purposes of construction and for use as fuel in domestic life and various avocations is an industry which forms the mainstay of thousands of men the world over, providing, as it does, employment of varied character, and securing large profits to the owners of forest areas be they private or public. It is an industry that should unquestionably be fostered by every means possible, and it is not referred to here to condemn it when properly carried out under judicious management; it is the *abuse* of it that calls for condemnation, and the next inquiry now is how the abuse is brought about.

Trees that have attained their prime should be felled when the maximum of value is obtainable, and the felling should be carried out in such a manner as always to leave the ground well covered by timber, older or younger, as the case may be; and there should invariably be enough old trees to ensure a supply of seed for a continuous growth of young seedlings to take the place of the older trees felled. The whole output should be regulated on the universally accepted principle among foresters that the forest as a whole constitutes the capital, and that only so much timber should be cut annually as is equivalent to the annual increase in growth made by the timber; that is to say, that the interest only must be taken and the capital left untouched. When this system is adhered to timber felling never degenerates into timber slaughtering, but the pity of it all is that under existing conditions when an experienced forester in a State forest in these colonies decides that enough timber has been cut and desires to reserve the rest the timber-getter gets up a memorial and secures the aid of the local Parliamentary representative, who depicts, in moving tones, to the central authorities the tragic circumstances of hardship under which the timber-getter is placed in being prevented from getting timber, which is, of course, in his opinion, abundant, and the result is that the faithful servant of the State takes a "back seat" as the reward of his disinterested service, while the sawyer or splitter gratifies his own self-interest at the State's expense. Thus one abuse occurs in timber felling. Another arises from the suicidal policy of cutting timber too young, to secure immediate profits, instead of waiting a proper time for fuller returns from larger timber—a practice often followed as a result of external pressure by those who clamor for prompt returns. Much more might be advanced, all tending to show wherein forest abuses lie. Suffice it to say that timber felling invariably gets abused unless carefully directed under a wise system rigidly adhered

to in the teeth of all representations from those who only seek their own individual aggrandisement.

The grazing of forest land acts both directly and indirectly in denuding the country of timber. Many trees in their seedling stage make excellent fodder, of which stock are not slow to avail themselves, and so direct and extensive is the damage done in this way that in some countries some species of shrubs and trees have totally disappeared owing to the incessant grazing by goats, which are probably the greatest curse to young trees in existence; camels are nearly as bad where they are common, and sheep, though not so universally the foe of every growing thing, commit very great havoc in our forests by devouring annually millions of tender trees when they possess but few leaves and are too small to be out of harm's way. This constitutes the great dilemma in the natural regeneration of old forests where small stock are depastured. The seeds spring up by myriads in special spots where they find a suitable seed bed, but only to be ruthlessly devoured unless they belong to a species unpalatable as fodder. Such a species to a certain extent is the red gum (*Eucalyptus rostrata*), which in our northern forest lands is the only tree standing any chance to reproduce itself by natural regeneration, because it is evidently unpalatable, whereas the sugar gum (*E. corynocalyx*) only rises to any height where protected by, perhaps, an old brush fence or heap of wood of similar dimensions that can afford it shelter from the hungry sheep, too often half-starved from overstocking. It is also in a large degree the inevitable result of this reprehensible practice of overstocking that so many young trees are eaten, for if grass were more abundant there would be more chance for the seedlings to escape, whereas when every source of food is heavily taxed they must perish. Moreover, every herb and edible shrub is eaten up as well, and thus, in an indirect manner, stock cause a large proportion of seed of trees to fail in germinating, because, the ground being hard and bare, no suitable seed bed is now available. Not only is the herbage gone which would have retained the light sandy loam and decayed vegetable matter collecting round it from time to time by the agency of the wind, but the incessant tramping of the land by the stock cuts up all loose soil (which then gets easily and speedily shifted by the first strong gale) and beats the harder soil down still harder, thus destroying all chance of seed either settling down or germinating.

The practice common in some places of firing shrubs and coarse grasses periodically to induce fresh growth is also a great enemy to natural regeneration by seedlings and a constant factor in the steady destruction of the older trees also, spite of the remarkable way in which some species, notably the stringybarks (*E. capitellata* and *E. obliqua*), are able to resist the injurious effects of bush fires. If it is possible to definitely regulate its action and effectually prevent its arising when not wanted fire can be made a useful

agent in germinating many of the seeds of our forest trees ; but the trouble often is that your seedlings that resulted from the germinating agency of fire in the first instance are perhaps scorched to death by a second fire just when you do not want or appreciate its services.

The custom of ringing trees to increase the growth of grass is another of the factors connected with grazing that result in the depletion of our forest areas. Not infrequently on badly-drained flats it produces swamps, and whatever increase in grass may result it is dearly bought when the timber is of large size and would be of considerable value at some future date. Of all methods of clearing timber it is certainly the most ghastly and uncanny in its effects on the landscape.

A kindred practice, and one responsible for a large amount of damage to one species of timber tree, is the felling of the sheoak (*Casuarina quadrivalvis*) for the sake of the very nourishing fodder contained in its leaves (so-called). This was practised largely in the earlier days, and thousands of acres have been denuded of these trees in hilly and other parts when grass has failed in bad seasons and "sheoaking" became an imperative necessity. The mistake was in felling the tree to its utter destruction when by judiciously lopping the main limbs—or "pollarding," to use the correct term—the same effect could have been secured, and the trees could still have continued performing the double function of growing fresh fodder and protecting the ranges from denudation.

The clearing and grubbing of land for agriculture and horticulture has caused the deforestation of considerable tracts of country. Where this clearing has been limited to plain lands and the upland of gentler grade no objection can be raised, except as regards the great want of judgment too often shown in failing to leave broad belts of timber for shelter against winds and clumps of trees for a protection for stock. The total clearance of all timber without regard to this very important consideration in many places has largely added to the trying and blighting effects of both hot and cold winds, and the clearing of the steeper hillsides for agriculture has produced very unsatisfactory results in many ways.

The various causes of deforestation having now been referred to, it remains to note the probable results.

The question naturally arises here as to what advantages the existence of forests secures to a country, and the reply will now be sought as briefly as may be.

A supply of timber is one advantage that most people readily admit can be derived from forests. There are other advantages, however, which, though possibly under some conditions even more vital to the welfare of a community, are not so readily perceived, and it is on this head that special comment is necessary.

Basing opinions on observations not always of the most complete or correct nature many have ardently supported the view, held by many, that forests decidedly increase the rainfall. Others maintain

the opposite view from observations which they, of course, deem equally convincing. Later meteorological observations, made by men fully convinced of the absolute necessity for the most rigid accuracy in all data of this description, have not hitherto been productive of more than an uncertain sound on the question; hence it is that the exact position of forests as climatic factors is a problem still awaiting solution. This is by no means the case, however, with regard to the influence of forests on springs and other living waters; still more with regard to the incalculably important function which they discharge in guarding the mountain ranges from the erosion of their soil and subsequent denudation. Here we can stand on firm ground, backed by well-authenticated facts. The general position is this: Forest trees intercept the rain as it dashes down and break the mechanical force of its fall, so that it finally drops gently upon the ground beneath. While the trees thus interpose themselves as a shield between the rain from above and the soil below, the deposit of twigs, bark, leaves, rotten wood, and other forest *debris* accumulated on the surface, it may be during the course of generations, absorbs a large amount of the rain as it drips from the trees; of the remainder much is carried downward through the innumerable channels offered by the millions of roots penetrating, often deeply, into the subsoil, leaving frequently but a small portion to flow off as surface water. Of this the force is broken, the volume divided, and the rapidity checked by the numerous obstacles existing on the forest floor in the shape of stems of trees, trunks, stumps, and roots, of fallen timber, mosses, fungi, and higher forms of vegetation existing more or less in all forests. The water which sinks into the soil is ultimately delivered by the processes of infiltration and percolation in a very gradual manner, at various points, according to the geological formation of the district, in the shape of springs. This, then, is the function discharged by forests regarding the springs:—They prevent the rapid disappearance of the rains in the short space of a few hours or days, and, in the way indicated, regulate the delivery of the water so gradually as to render the supply sufficient till reinforced by subsequent rains. Respecting the power of the forest as a factor in regulating the surface flow of storm waters, it must be borne in mind that exceptional circumstances as regards the amount of rain precipitated, the topography of the country, and character of the soil may modify it to a certain extent; but, while this is the case, the important fact remains that the normal condition of forest soil, anchored as it is by millions of roots, is proof against all attempts at erosion, and defies the storm to tear it from its place or hurl it, in the form of detritus, into the valley below. Forests, then, prevent the formation of torrents and the denudation of the area of country on which they grow.

Other influences of greater or lesser importance may be attributed to forests, but inasmuch as those specially indicated have the most

direct bearing on every day life and work, they claim priority of consideration in the limited scope of this paper.

From amongst the great mass of evidence available in support of the foregoing statements a few brief selections will now be made.

A Forest Commission, which was appointed in 1881 in the State of New Hampshire, U.S., to inquire, among other matters relating to forests, "on the effect, if any, produced by the destruction of forests upon the rainfall, and consequently upon the ponds and streams," presented a general summary of evidence in 1885, from which the following extracts may be given:—

"Beginning with the southern portion of the State and with the town of Richmond, attention is called to a small stream there, which in 1865 furnished sufficient power for four sawmills nearly all the year, but which began to dry up with the more rapid removal of the timber caused by the introduction of steam as an auxiliary power. The water and the woods have disappeared together, and the same is the case in the other portions of the town."

"In Canaan sixty-five years ago there were nine or more mills of different kinds; abundant water power all the year round: no thought of reservoirs or precautions against drought. Canaan-street, now covered with a firm dry sod, was laid out through a swamp, impassable but for the hummocks and fallen trees, while dense forests of giant trees covered the hills. The writer who furnishes the above facts, a native of the place, returning after an absence of thirty years, found the hills and rocks bare, the springs choked up, and the mills obliged to resort to steam power or lie idle."

In their concluding remarks the Commissioners said:—"On one point there is no division of opinion. It is not in the open ground, but beneath the trees, that the moisture and snow accumulate and are slowly and surely supplied to the springs and streams, which then have a perennial flow. Let the same ground be deprived of its shade, and this exposure to the sun hastens evaporation, and the rain and melting snow rapidly pass off through the water-courses before any sufficient quantity can reach the permanent reservoirs under the surface. The surface itself is often washed off and the exposed rocks given over to perpetual barrenness."

The Superintendent of Public Works of the State of New York, reporting on the effect of the removal of forests in the Adirondack watersheds upon the navigation of the canals, says, in report for 1882:—"The importance of the preservation of the woods in the Adirondack region in connection with the water supply of the canals cannot be over-estimated. With the continual cutting away of the forests and the burning of the forest floor the decreasing water supply has become painfully apparent. Should this continue the result on the canals would be disastrous."

So much as to the influence of forests on springs. Let us now turn to their relation to torrents and their results. The history of some departments in the south of France has shown that the so-called torrential action of water has devastated thousands of acres of fertile land by carrying the detritus into the valleys and depositing it there; but at the same time the reforestation work of the French Government has gone far enough to prove that the reclothing of the denuded hills with timber is the practical remedy against these torrents. Not only were the mountain sides themselves devastated and made useless by the destructive action of the torrents formed after the felling of the forests, but fertile farms for 200 miles from the source of the evil were ruined by the deposit of the *debris* and the population pauperised and driven out. The area of denuded mountain lands requiring reforestation was estimated in 1886 by M. Demoutzey, Forest Administrator of France, as being 2,964,000 acres. Of this some 780,000 acres of the most injured area have been restored by the Government at a cost of some £2,000,000, and private owners have expended some £4,000,000 to remedy the past folly of devastating the forests by replanting them; and all this is reckoned as only about half what is required. The clearing of woodland and the organisation of a police for its protection are regulated by a law bearing date June 18th, 1859, and provision was made for promoting the restoration of private woods by a statute adopted on July 28th, 1860. Mr. Geo. P. Marsh, United States Minister at several European courts at one time, well remarks, in alluding to these laws in his work, "The Earth as Modified by Human Action":—"When it is considered that both laws, the former especially, interfere very materially with the rights of private domain, the almost entire unanimity with which they were adopted is proof of a very general popular conviction that the protection and extension of forests is a measure more likely than any other to arrest the devastation of torrents, and check the violence, if not prevent the recurrence, of destructive river inundations." The work just referred to, together with a valuable bulletin on "Forest Influences," published by the United States Department of Agriculture during the present year, and written by Mr. B. E. Fernow (Chief of the Forestry Division), and "Reforestation in France," by Rev. J. C. Brown—to all of which I am indebted for valuable information on these matters—all teem with striking illustrations of the vast importance of this subject, but, though exceedingly interesting, space will not admit of further references.

And now the question arises, as we think of the history of forest devastation in other lands—France, Italy, Spain, Portugal, America, India, and many others—is there any particular reason why these colonies in the Southern Hemisphere should escape similar results when similar causes are at work? and, if so, why are we to enjoy immunity from the bitter experience of others?

It is one thing to ask the question; it is quite another to get a reassuring answer. What, then, are the probable results of deforestation in South Australia and, relatively, to other portions of this continent?

The result regarding the timber supply is very marked. The best timber available under present conditions of price and labor has without doubt been cut. Something has been done by the State in planting, and although that work will undoubtedly prove a thoroughly paying one, it is a drop in the ocean compared with the area required to supply the demand for timber which will arise when supplies from other lands get more restricted, the probability of which gets stronger and stronger. In many quarters the failure of outside supplies is regarded as a matter of the strongest improbability; they who hold such views quite overlook one thing, namely, that the amount of timber in a virgin forest that gets fairly treated and utilised to the full is as nothing to the vast quantity that gets scandalously wasted by lumber men and destroyed by fires. Late in the day, when all the best forest areas in South Australia, lying nearest to centres of industry, and therefore capable of yielding better revenue, had passed into private hands, the importance of forest reservation was recognised, and such forest areas as were still available were placed under systematic oversight. The total area thus reserved amounted to under a quarter of a million acres, and even of this only about one-third could justly be termed proper forest land, the remainder being mere scrubby inferior growth not worth the name of timber. It seems as if the trend of present land legislation is toward undoing everything that was formerly attempted in the way of forest conservation; and thus it appears probable that history may repeat itself, inasmuch as it was under pressure of temporary exigencies in other countries that the forest areas were devastated without regard to the results in store for future generations.

As a matter of fact, the indifference regarding the regeneration of our forest areas has caused the disappearance of every considerable area of the red gum (*Eucalyptus rostrata*), the timber of which, when of best quality, can be excelled by few timbers the world over for certain purposes. The blackwood (*Acacia melanoxylon*), a beautiful and most useful timber for manufacture for ornamental purposes, and carriage-builders' uses, which at one time was procurable in saleable quantities from our Mount Lofty Ranges, is now all imported; while, in the South-East as well as in the Adelaide tiers, the stringybark (*Eucalyptus obliqua*), a timber of considerable utility in some ways, stands poor chance of increasing by self-sown seedlings owing to the practice of burning the forest tracts to increase the fodder supply in the South-East and to clear the hills near Adelaide. These fires frequently "get away" from the tract they were intended to operate on, and often effect a vast amount of mischief. As all good timber will cer-

tainly increase in value, it seems a matter for great regret that much of the land carrying such timber should be held at a ridiculously low figure per acre—perhaps only 1½d. or 2d.—for grazing purposes, and that the occupiers of such land should be able to do such an amount of damage by firing the country as first indicated; and yet the difficulties in the way of prevention are so great, owing to the lack of recognition of the importance of definitely repressive legislation in this matter, that little can be done to prevent it.

Regarding the effects of deforestation in this colony on springs, &c., there are yet no data available, as but scant interest has apparently been taken in the way of making any observations; but it may safely be asserted that wherever the surrounding conditions of springs as to forest cover in any degree correspond to those in other countries where the removal of timber has produced failure of the springs, there can be no warrant for expecting any immunity from similar results as a consequence of similar causes.

On the question of erosion of soil by the agency of rain rushing over surfaces once timbered and now bare of timber ample evidence can be found in various directions in this colony. I can point to many spots within the scope of my own observation, and travellers by either the Northern or Southern railway, if trained to close observation, can soon detect similar spots themselves. In cases where undulating land of fairly steep grade has been cleared of its timber and ploughed for, perhaps, years and then abandoned to grazing much damage has been done, and the mischief has been specially aggravated in cases where the furrows have run up and down the hill instead of all along it. Here the storm water, falling unopposed on the soft ground, unprotected by the good matted vegetation that would have existed but for heavy overstocking and cultivation, cuts its way without trouble deeper and deeper every successive rain; other rifts appear at brief distances along the same hill side, and ultimately extend over a large area which they render comparatively useless. Other instances might be quoted, but enough has been stated to show that even in the present early stage of this colony's history the evils which have wrought such havoc in other lands are already definitely showing themselves and reducing the question to one merely of time and degree.

With reference to floods, there can be no question that, to a greater or less degree, the same causes that deluged the fertile plains in other countries with rocks and *debris*, sand, and flood drift are commencing their fearful work here; if not, how is it that the Torrens dam gets so silted up? It is no answer to say it is only sand, or that the flood deposit is rich alluvial soil that is a vast benefit to many a dweller by the river's course. The best land is always washed from the uplands first; then the rocks and stones. If the good land has now for some time enriched some

parts, is there any assurance that in later years the more useless *debris* will not also appear on the scene as in other lands? Might it not be a pertinent inquiry in this connection to what extent the late terrible floods in Queensland were due to unwise clearing of forest lands, or whether they were entirely the result of phenomenal rainfall?

Here, then, is a statement of the disease. The remedy will be found when every individual member of an intelligent democracy shall, after careful study of the deplorable tale which the history of forest devastation has to tell, take warning by the ruinous experience of other nations, and recognise the fact that the forests of a country are not the property of the first man who chances to grab them, be he sawmiller or farmer, blocker or squatter; that they are national property, productive of national benefits, and should, therefore, be legislated for on such a broad national basis as to ensure the wise preservation for posterity of an equal share of similar advantages to those we have ourselves derived from them.



2.—THE PHYSICAL PROPERTIES OF THE CONSTITUENTS OF THE SOIL.

By J. G. TEPPER, F.L.S.



3.—AGRICULTURAL WEALTH.

By W. SMITHERS GADD.



4.—TAXATION: CURRENT FALLACIES.

By R. M. JOHNSTON, F.L.S., Government Statist of Tasmania.



5.—THE PROPER METHOD OF LEVYING A LAND TAX

By C. W. ADAMS.

6.—A PLEA FOR AN INTERCOLONIAL STATE BOARD OF HORTICULTURE.

By A. MOLINEUX, F.L.S., F.R.H.S., &c.

I am desirous to submit this question in the most concise form possible, leaving those to whom the idea may prove acceptable to elaborate and, if possible, bring it to a practical conclusion. A very considerable number of people in Australia gain their living by the practice of horticulture, and the whole of the population is dependent upon them for many of the principal necessities of life. For instance, in South Australia alone there are more than 1,000 persons cultivating orchards and gardens over five acres in area, and a majority of the people cultivate smaller gardens. In Victoria and New South Wales, of course, the numbers of persons engaged in horticulture are greater, whilst in Queensland they probably equal those in South Australia. It is, then, most important that those cultivators should be enabled to make the best use of their opportunities, for upon their success and prosperity depends also the prosperity, comfort, and health of the general community.

It has been calculated that the fruitgrowers in Angaston district and southwards to Adelaide annually lose £10,000 worth of apples, pears, and apricots through the effects of three parasitic fungi introduced from other countries, viz., *Fusicladium dendriticum*, *F. pyrinum*, and *Phyllosticta circumcissa*, commonly known as apple, pear, and apricot scabs. In addition to these pests the unfortunate growers have to contend against numerous other parasitic fungi, eel-worms, scale insects, borers, and other ravagers, which are constantly being multiplied by new introductions from other countries.

No estimate of the total annual loss to the colonies from the depredations of these numerous pests has ever come under my notice, but it must certainly amount in the aggregate to hundreds of thousands of pounds.

That the greater part, if not the whole, of this enormous annual loss is preventible can be shown by the results of scientific inquiry and consequent recommendation in other countries. Pasteur discovered the cause, and indicated the remedy for the silkworm disease. *Oidium* of vines is no longer feared because sulphur supplies the remedy. Colorado beetles threatened the existence of the potato, but Paris green was found to be effectual against this and numerous other insects of a similar habit. Scab in sheep, foot and mouth disease, rinderpest, actinomycosis, and many other affections of our live stock have been successfully resisted. The *Novius* (*Vedalia*) *cardinalis* was introduced by the efforts of science to Southern California and Cape Colony, and within a very short time the *Icerya Purchasii*, which had previously been introduced into each of those countries and had taken entire possession of orange and other fruit trees, was utterly exterminated. The

researches of scientific experts have in innumerable cases enabled agronomists to overcome apparently insuperable difficulties, and industries which for a time have been threatened with extinction have by the aid of science been restored to more than pristine vigor.

Again, the number of named varieties of fruits, &c., is enormous; their characters and qualities are as varied as their names, although probably two dozens of varieties of apples or pears, or less of other fruits, would comprise all that are really worthy of perpetuation. Each of the best of the varieties possesses from two to a dozen synonyms, and these duplicated names belong also to other varieties, which also have several names, so that it is not possible to arrive at the proper nomenclature. Thus an intending grower may plant a large area with quite a different variety to that which he intended for a particular purpose—such as for export in a fresh condition, or for canning, drying, or otherwise—and the consequences to him may be disastrous.

The greatest credit must be given to the officers in the Departments of Agriculture of New South Wales, Victoria, and Queensland. Dr. N. A. Cobb, Messrs A. S. Olliff, F. Turner, J. H. Maiden in New South Wales, Messrs. Charles French, D. McAlpine, and G. Neilson in Victoria, Mr. C. W. de Vis in Queensland, and others, have done noble service in their various sections so far as the means and facilities at their disposal would allow; but it is possible that one thoroughly-equipped organisation would be able to do better work than several small agencies could perform, and doubtless a deal of useless duplication might be avoided. My suggestion, then, is that the whole of the colonies should unite to establish a central agronomical station, where every possible kind of fruit, vegetable, cereal, and plant of economic value should be grown for observation and for educational purposes (students being trained in connection therewith). There should be a museum of economic botany, vegetable pathology, economic entomology, &c., attached: models of the best fruits as they appear under varying circumstances of soils, &c.; a laboratory for analyses—in fact, the institution should be provided with everything in reason that the scientific staff could require in order to enable them to properly carry out their work.

The staff should comprise a director-general, at least one vegetable pathologist, one economic entomologist, analyst, a practical horticulturist and pomologist, and such minor officers as may be needed. Additionally, there should be honorary correspondents appointed in all parts of the colonies where possible. There are many specialists in the colonies who would be only too willing to act in such a capacity, and their labors would be of the greatest assistance to the proposed institution.

Whatever expenses might be incurred would be recouped a thousandfold by the introduction or discovery of a remedy for any

one of the pests from which our cultivators suffer. Not one colony, but the whole of the colonies, cannot but benefit from the labors of such a body of scientific men, and any discoveries which tend to ameliorate or to defeat the ravages of any one or more of those pests must be of equal value to all of the colonies; therefore, the whole of the colonies should unite to establish a Federated State Board of Horticulture.



7.—LABOR, LAND, AND REVENUE.

By A. B. BIGGS.



8.—THE PUNISHMENT OF CRIMINALS.

By W. H. BUNDEY, a Judge of the Supreme Court of South Australia.

QUESTION ATTRACTING THE ATTENTION OF SCIENTIFIC AND THOUGHTFUL MEN—WIDE DIFFERENCE OF OPINION UPON IT.

The subjects referred to in the following remarks are probably unattractive to many people. It is, however, unfortunately impossible for all to avoid their consideration, as those placed in the position of administrators of the Criminal Law have but too good reason to know.

There can be no doubt that at the present time very great interest is taken by reflective men in the question of the punishment of criminal offenders. This tendency is especially noticeable in scientific and literary circles. In England, in America, and in the Australian Colonies we find articles in reviews and newspapers, letters to the press, and occasional references upon public platforms, all testifying to the thought that is being given to the subject. It is most interesting to note how widely divergent are the views expressed. For want of a better definition, I will define them as the two extremes and one moderate currents of opinion. Following the example of past generations, one portion of the community advocates exemplary punishment, and appears to adopt, to some extent at least, the views propounded by the great criminal jurist, Sir James Fitzjames Stephen. That learned and fearless Judge in effect says the Criminal Law proceeds upon the principle that it is morally right to hate criminals, and highly desirable that criminals should be hated; that the punishment inflicted upon

them should be so contrived as to give expression to hatred, and to justify it so far as the public provision of means for expressing and gratifying a healthy natural sentiment can justify and encourage it, and that whatever may have been the case in periods of greater energy, less knowledge, and less sensibility than ours, it is now far more likely people would witness acts of grievous cruelty, deliberate fraud, and lawless turbulence with too little hatred and too little desire for deliberate measured revenge than that they would feel too much ; and he states his observation and experience of criminals to have been that there are in the world a considerable number of extremely wicked people disposed, where opportunity offers, to get what they want by force or fraud, with complete indifference to the interests of others, and in ways which are inconsistent with the existence of civilised society. Such persons, he thinks, ought, in extreme cases, to be destroyed. The learned Judge says these views are regarded by many persons as being wicked, because it is supposed that we never ought to hate or wish to be revenged upon anyone, but that it is useless to argue upon questions of sentiment, and all that one can do is to avow the sentiments which he holds, and denounce those which he dislikes.

But it would be unjust to so able and distinguished a Judge as Sir James F. Stephen, one to whom England owes so much for his great labors both there and in India, to take one or two extracts from his voluminous writings without, at the same time, showing from one of the very first principles of penal justice how strong he may have felt his grounds to be. It must be remembered that the foundation-stone of the Criminal Law is the yielding up of individual hatred, or temptation to revenge for the retributive justice of the State. The earliest laws of all civilised communities show that as they advanced in civilisation it was agreed that the individual injured by a crime should not personally retaliate, but should have recourse to the tribunals appointed to administer the Criminal Law, who alone were empowered to apportion the degree of punishment authorised by the framers of the law, always, of course, subject to its being reduced by those endowed with the prerogative of mercy. It is self-evident that the abandonment of private revenge for the measured and unimpassioned justice of the community was, and is, absolutely necessary ; as otherwise peace, order, and good government would be impossible. The common and statute law provide for penalties according to the heinousness of the offence and the wrong done to the individual. If these are inadequate, or inefficiently carried out, then dissatisfaction is sure to ensue, and still more dissatisfaction arises if the punishment is excessive and altogether out of proportion to the crime. Let me illustrate the preceding remarks. Supposing a cruel murder is committed, and capital punishment is the law of the land, then the death penalty should be enforced ; otherwise the friends of the murdered man or woman would be sorely tempted to take life for

life. This might lead to a continual vendetta and numerous other murders, such as we read about in Virginia and some of the other American States, where, it is alleged, criminals often escape from justice or the law is not firmly administered. The argument is, of course, applicable to any other crime of a malevolent or brutal character. Some years ago, when the garotters in England had the lash freely applied to them the whole community were gratified, because it was just retribution for the suffering the criminals had inflicted on their victims.

Looking at Sir J. F. Stephen's advocacy of the hatred and revenge theory from the preceding standpoint, it will be seen that his opinions are not the mere groundless expressions of a relentless Judge. He may well contend that he was but giving effect to views founded upon acknowledged principles of the Criminal Law. I am presumptuous enough to differ from such views, and to express the hope that they will never be followed. The main object of this paper is to advocate a far more merciful, but, it is believed, an equally efficacious, way of relieving the community of its anti-social portion. We do not want to stain our criminal annals with more blood. The remembrances of the past are sickening enough in this respect.

In 1771, when the Criminal Law was administered in a spirit that would not be tolerated in these more enlightened days, Lord Auckland published his "Principles of the Penal Law," a work still esteemed one of the ablest written upon the subject. The following sentence from it will show how greatly at variance he is with Sir J. F. Stephen as to the spirit in which criminals should be punished. He says:—"There is no such thing as vindictive justice; the idea is shocking." Mr. Nesbit, Q.C., in his address on "Insanity and Crime," at Hobart, in January, 1892, dealing with this aspect of Sir J. F. Stephen's teachings, is reported to have said:—"Between the hatred which Sir James Stephen justifies and the majestic severity of the mind which, while detesting crime, can still regard the criminal as an erring and deeply unfortunate brother the gulf is wide indeed. Can we doubt which is the most worthy of a high moral nature and of a truly strong character?" In cases of premeditated and malevolent injury, where the conscience has ample time to warn, strong exception may be taken to the terms "an erring and deeply unfortunate brother." In such cases one feels that *lex talionis* is the most fitting punishment, and the accused is entirely removed from the category of the unfortunate.

But the term is not inapplicable to some who have yielded to sudden impulse or temptation. There is often much force in what a late English Judge, noted for his ability and fairness in criminal cases, once said in reference to prisoners—"They are just like other people; in fact, I often think that but for the different opportunities and other accidents the prisoner and I might very well be in one

another's places." I, however, fully agree with Mr. Nesbit, that neither a harsh nature nor harsh punishments on the part of a Judge prove him to be a strong character. The brave and strong have sometimes to be "cruel to be kind"; but the really brave and strong nature never willingly inflicts needless pain.

At the other extreme from the stern and unsympathetic school are those who advocate what has been rather expressively, although not euphoniously, called "coddling criminals"—the sentimental school who, it is averred, are continuously raising the "poor dear criminal" cry. It is unnecessary to enlarge upon the views of these good people, because they are generally very much in evidence before the public, often alleging that our whole criminal procedure is erroneous, that imprisonment does not act as a deterrent of crime, and that criminals are only society's failures, and should be reformed solely by kindness. Without stopping to inquire whether such views will stand the test of reason, they seem to me sufficiently answered by the author of "Crimes and Punishment," when he says, "Shall we suppose for a moment that society would cease to punish on the ground that punishment attained none of its professed aims? Would it say to the horsestealer, 'Keep your horse, for nothing we can do to you can make you any better nor deter others from trying to get horses in the same way'?"

I think we may safely conclude that the present system will survive the attacks made upon it on such grounds. Not that it is by any means perfect. Every student of the Criminal Law and its procedure knows how often it has been altered and how frequently defects are discovered. Indeed, in the very nature of things this must be so. To alter and amend, however, is one thing; to totally abrogate is quite another matter. The third or moderate current of opinion previously alluded to recognises this, and is desirous of assisting in every beneficial amendment of the Criminal Law whilst avoiding the two extremes already dealt with.

If the foregoing remarks are well grounded they serve to show two essential elements in the framing of the penal law, viz.:—(1) That punishments shall be so apportioned and certain as to discourage all attempts at private revenge. (2) That they shall be of such a nature as to satisfy the just but unimpassioned resentment of the community. Whenever this has been overlooked or departed from trouble has ensued.

A PASSING GLANCE AT THE PUNISHMENTS AWARDED IN BYGONE DAYS, AND THE EFFORTS MADE FOR THEIR AMELIORATION.

In 1771 there were upwards of 200 crimes punishable with death. Up to 1837 there were still thirty-seven capital offences. Happily there are now only four, viz., treason, murder, piracy with violence, and setting fire to dockyards and arsenals.

About 1770 there appeared in Italy the celebrated work by Beccaria, "Crimes and Punishments" (*Dei Delitti e delle Pene*). Bearing in mind the state of the Criminal Law in Italy and throughout the Continent of Europe at the time of its publication, it is a marvel of advanced thought and high courage as well as of great literary ability. Its effect was remarkable, especially in Russia, France, Austria, and England—it gave the deathblow to the horrible torturing of prisoners then in full practice in most, if not all, the countries mentioned except England. Torture had previously been abolished in England, except in one particular. If a prisoner remained silent, or refused to plead to an indictment, he was squeezed nearly to death with an iron weight. This practice continued until 1771.

Beccaria's writings produced an especially powerful effect on the mind of Catherine II. of Russia. She determined to try and establish a uniform penal code founded on the ideas he had formulated. She caused 652 deputies to be summoned to Moscow from all the provinces of Russia, and the translator of Beccaria's work remarks that the assemblage formed the nearest approach to a Russian Parliament disclosed in the history of that country. The following were some of the instructions that were read to this assembly as a basis for the proposed codification of the laws, and they will serve to show the general tenor of Beccaria's theories:—

"Laws should only be considered as a means of conducting mankind to the greatest happiness."

"It is incomparably better to prevent crimes than to punish them."

"The aim of punishment is not to torment sensitive beings."

"All punishment is unjust that is unnecessary to the maintenance of public safety."

"In the methods of trial the use of torture is contrary to sound reason. Humanity cries out against the practice, and insists on its abolition."

"Judgment must be nothing but the precise text of the law, and the office of the Judge is only to pronounce whether the action is contrary or conformable to it."

"In the ordinary state of society the death of a citizen is neither useful nor necessary."

"Would you prevent crimes? Contrive that the laws favor less different orders of citizens than each citizen in particular. Let men fear the laws, and nothing but the laws. Would you prevent crimes? Provide that reason and knowledge be more and more diffused. The surest but most difficult method of making men better is by perfecting education."

Beccario was a very strenuous advocate for the abolition of capital punishment. Shortly summarising his argument, it is as follows:—

The death penalty is a war of a nation against one of its members because his annihilation is deemed necessary and expedient.

It is not the terrible, yet brief, sight of a criminal's death, but the long and painful example of a man deprived of his liberty, who, having become as it were a beast of burthen, repays with his toil the society he has offended, which is the strongest restraint from crimes. Far more potent than the fear of death, which men ever have before their eyes in the remote distance, is the thought, so efficacious from its constant recurrence, "I myself shall be reduced to as long and miserable a condition if I commit similar misdeeds." The intensity of punishment of penal servitude for life, substituted for capital punishment, has that in it which is sufficient to daunt the most determined courage. To me it seems an absurdity that the laws which are the expression of the public will, which abhor and which punish murder, should themselves commit one, and that to deter citizens from private assassination they should themselves order a public murder.

Although this was written nearly 150 years ago, at a time when the rack and other horrible instruments of torture were employed in the administration of justice, and when it was highly dangerous to express such opinions, it will be difficult to find the arguments in favor of the view he supports put more forcibly or succinctly, however erroneous one may think them. Is it, however, a fallacy to call a State execution of one convicted of homicide a murder. The same authority that gave the command, "Thou shalt do no murder" also said, "Whoso killeth any person, the murderer shall be put to death by the mouth of witnesses, but one witness shall not testify against any person to cause him to die. Moreover, ye shall take no satisfaction for the life of a murderer, which is guilty of death; but he shall be surely put to death." The assassin is disobeying the law of God and man when he murders a fellow-creature. The State is obeying the express command of the Divine Lawgiver and its own laws when it exacts the murderer's life as the penalty. But time will not permit of further dissecting the argument.

Although nearly all Beccaria's writings tended towards the merciful treatment of offenders it is curious to note that he, in common with Montesquieu and Bentham, advocated analogy between crime and its punishment; but, as pointed out by other writers, the principle has in its favor the authority of Moses, the authority of the whole world, and of all time, that punishment should, if possible, resemble in kind the crime it punishes; so that a man who blinds another should be himself blinded, he that disfigures another be himself disfigured. Thus in the old-world mythology Theseus and Hercules inflict on the evil powers they conquer the same cruelties for which their victims were famous. Bentham was less pronounced in its favor than Beccaria and Montesquieu; nevertheless he recommended burning for arson, and the transfixing of a forger's hand or a slanderer's tongue by an iron instrument as punishments for the respective crimes mentioned.

Hobbes, however, taught the doctrine now acted upon. He wrote—"In revenges or punishments men ought not to look at the greatness of the evil past, but for the greatness of the good to follow, whereby we are forbidden to inflict punishment with any other design than for the correction of the offender and the admonition of others."

Not only was Beccaria's influence deeply felt in his own country and the others named, but Mr. Farrar, the recent translator of his work, claims for him the premier position in the improvement of the penal laws of our mother land. He says there is no English writer of that day who, in treating of the Criminal Law, does not refer to Beccaria. Lord Mansfield is said to have had the highest respect for him, and his work is referred to in appreciative terms by Blackstone, Paley, and Bentham. The latter acknowledges that Beccaria was the first that taught him to pronounce this sacred truth, "That the greatest happiness of the greatest number is the foundation of morals and happiness."

It is manifestly impossible to bring under your notice the various individual efforts to repeal the death penalty in England for trivial offences. Only one or two can be referred to, in order that some idea may be gathered of the difficulty encountered. In 1770 Sir William Meredith obtained a committee of inquiry into the state of the law, and some slight modifications were made. Looking at these laws from our present vantage ground, it makes one feel ashamed that it was possible such could exist. How differently they were esteemed at the time may be gathered from the fact that when, towards the end of the last or in the beginning of the present century, Lord Abinger advised Lord Romilly to introduce a Bill to repeal all statutes punishing mere theft with death, he abandoned the idea as useless. Later (1808) he succeeded in carrying, after great opposition, a Bill to abolish this dread penalty for stealing a handkerchief or other articles from the person to the value of 1s. All the leading lawyers in both Houses opposed it, and Lord Ellenborough, one of England's most renowned Judges, said, "If any change in punishment were necessary, it should be transportation for life." One may almost exclaim that it seems incredible; and if many of the convicts of that time were sent out of the mother country for such trivial offences, they were really more objects of compassion than contempt. Lord Ellenborough, according to Mr. Farrar, enjoys the melancholy fame of having been the inveterate and successful opponent of nearly every movement made in his time in favor of the mitigation of our penal laws. A singular result followed from Lord Romilly's success. After the passing of his Bill stealing apparently became more frequent, as was predicted by the opponents of abolishing the death penalty. It was no use to point out to them that people previously refrained from prosecuting because they preferred to suffer loss rather than be the means of sending a fellow-creature into eternity. Lord

Romilly made many subsequent efforts in the same direction, but they were rendered fruitless by the opposition he encountered through this apparent increase of crime. Archdeacon Paley, in his "Moral and Political Philosophy" (a work that for many years had, as we all know, immense influence on English thought), approved of the suggestion to "cast murderers into a den of wild beasts, where they would perish in a manner dreadful to the imagination, yet concealed from view," and at the same time protested against the maxim "That it was better for ten guilty men to escape than for one innocent man to perish," and argued that an innocent man being convicted and punished fell for his country, because he was the victim of a system of laws which maintained the safety of the community. When such was the teaching of the best minds of the age it is not surprising that it was found difficult to repeal what are now deemed inhuman laws. However, thanks to Beccaria's teachings and the efforts of other humanitarians, including with those previously mentioned the honored names of McIntosh, Howard, Mrs. Fry, and many others, success eventually crowned their labors.

Before concluding this passing glance at our forefathers' ideas and practice in regard to their penal laws it may not be uninteresting to note that they did not end in punishing human beings. In the middle ages pigs, horses, or oxen were not only tried judicially like men, with counsel on either side and witnesses, but they were hung on gallows like men, for the better deterrence of their kind in future. (See Mr. Baring Gould's "Curiosities of Olden Times," title "Queer Culprits.") This was following the Jewish law which condemned an ox that gored anyone to death to be stoned, just as it condemned the human murderer. In Athens an axe or stone that killed anyone by accident was cast beyond the border, and in England a cartwheel, a tree, or a beast that killed a man became forfeit to the State for the benefit of the poor. This custom was called Deodand. (Deodandum, what is due to God.) It is mentioned by Bracton, one of the earliest writers on English law, who lived in the reign of Henry III. The translation of his description into English is as follows:—

What moves to death, or killed the dead,
Is Deodand, and forfeited.

It was not until 1846 that an Act was passed repealing the custom, declaring it to be unreasonable and inconvenient. Probably this declaration will not be disputed by many.

Anyone desirous of supping full of the horrors caused by the old penal laws and their administration should read Lecky's "Rise and Influence of Rationalism in Europe," title "Magic and Witchcraft." Past history of punishment proves that although the administration of the Criminal Law was marked by footsteps of blood from age to age, it neither cured nor effectually lessened crime. Attention has already been called to some of the reasons

for this. Many would not prosecute, and juries were naturally loth to convict; or, in other words, harsh and cruel laws and punishments have been tried, and failed—a point it is desired to emphasise.

SOME OBSERVATIONS ON PUNISHMENTS UNDER THE PRESENT LAW.

The next question it is proposed to consider is, "Does the present Criminal Law require amendment? and, if so, in what respect is it capable of improvement?"

The admitted objects of punishment are—(1) To reform the criminal. (2) To deter others from committing crimes. Now, although undue severity has failed to attain these objects, it is open to doubt whether the pendulum has not swung too far the other way. The abolition of the death penalty for crimes other than murder was in accordance with natural justice, but in the extreme reaction a not altogether healthy sentiment appears to have been evoked in some communities. We find sympathy expressed for murderers of the worst class, and after sentence the Executive are invoked to remember the sacredness of human life. The well-known answer of Talleyrand, "Let messieurs, the assassins, begin by remembering this," ought surely to express the sentiments of every well-regulated community.

In America there are two degrees in murder. These degrees were first defined in Pennsylvania in 1794; the same principle is adopted in most of the other States. A murder deliberately premeditated with malice aforethought would be one of the first degree, and where an American jury would find a verdict of murder in the first degree it is open to grave question if any sentimental consideration should prevent the law being carried out.

Sir H. Maine, in his "Ancient Law," upon this subject says:—"Like every other institution which has accompanied the human race down the current of its history, the punishment of death is a necessity of society in certain stages of the civilising process. There is a time when the attempt to dispense with it baulks both of the two great instincts which lie at the root of all penal law. Without it the community neither feels that it is sufficiently revenged on the criminal, nor thinks that the example of his punishment is adequate to deter others from imitating him."

No one will dispute that there are many cases coming within the legal definition of murder in which it would be unjust to inflict the death penalty, but these would never be comprised in the American category of murder in the first degree. It is not my intention to enter into the ever-recurring controversy as to whether capital punishment is justifiable or not. Judges have to administer the law as it exists, but it is a matter worthy of consideration whether some more certain method than that now prevailing should not be adopted as to the carrying out of sentences.

It does not tend to the better administration of justice that any of its proceedings should be rendered liable to be looked upon as a solemn farce. In England, when there were a considerable number of felonies still punishable with death, it came to be considered that to pass sentence of death in cases in which the penalty was not intended to be carried out was objectionable, and accordingly in 1823 a special Act was passed upon the subject (see 4 Geo. 4 c. 48), which enabled the Court to abstain from actually passing such a sentence, and simply order it to be recorded, which had the effect of a reprieve. This, of course, has not been applied to cases of murder. A Judge has no alternative but to pass sentence of death on such a finding; but the passage of such an Act shows how mischievous it is for anything in the nature of a pretence at punishment to be continued.

One seldom hears anyone defend the present system of allowing murderers imprisoned for life to mix with their kind again after a few years' incarceration. Even the strongest advocates for the abolition of capital punishment admit that a premeditated, a revengeful, or a brutal murder should be looked upon with such abhorrence that the murderer should be securely kept apart for the remainder of his natural life. The certainty of this being done would remove one of the greatest objections to the abolition of capital punishment in the minds of many who now support its continuance. The contention is that such an anti-social and dangerous being has by his own acts proved himself unfit to be again thrown upon society, and in the minds of many it is an outrage upon the community that this should be permitted.

INADEQUACY OF PUNISHMENT FOR OFFENCES AGAINST THE PERSON. — TOO GREAT SEVERITY FOR OFFENCES AGAINST PROPERTY.

Whatever may be the opinions of those who have to administer the Criminal Law on the preceding question, there is no doubt about their unanimity as to the inadequacy of punishments provided for offences against the person. They are, I believe, almost equally unanimous in holding that the punishments enacted for offences against property are unnecessarily severe. My authority for these statements, so far as England is concerned, is Mr. Justice Hawkins. In a recent issue of "The New Review" that learned Judge calls attention to the lightness of the sentence for cruel and violent assaults, perhaps on women or children, and the severity of those for trifling acts of dishonesty, and adds that this condition of things is recognised by the whole body of English Judges as in the highest degree detrimental to the interests of justice; and, in consequence, a council of that body some time ago resolved in substance that it was desirable to establish a court for the revision of such sentences. He does not, however, speak hopefully of the scheme. The present Criminal Law of South Australia requires

amendment in both particulars. Two years can be awarded for stealing a pocket-handkerchief, and only three years for an aggravated assault without a weapon, but which may cripple the man or woman assaulted for the remainder of his or her days.

With all his humanitarian tendencies, Beccaria took a very determined stand on this point. He writes:—"It is against crimes affecting the person that punishments are most desirable and their vindictive character most justly displayed. Personal violence calls for personal detention or personal chastisement, and the principle of analogy in punishment is most appropriate in the case of a man who maltreats his wife or abuses his strength against any weakness greater than his own."

The satirical remarks of Max O'Rell in "John Bull and his Womankind" show what foreigners think of the absurdly light sentences upon brutal English wife-beaters, and it is a matter well worthy of consideration whether such, and all offenders guilty of ruffianly violence to others, ought not to be made liable to corporal punishment in some form.

Many of the assaults now dealt with by magistrates, and in which sometimes mere nominal money fines are inflicted, ought to be punished by imprisonment, with power for the Bench to also fine, and order the fine, or such portion of it as they may deem just, to be paid to the injured person, and thus save the necessity of recourse to a civil court for compensation in damages. It has been well said that the law condescends to and considers human frailty, but it ought not to tolerate human ferocity. To my mind the offence of purloining some trifling article, it may be from a clothes-line, is not to be compared, for the suffering it entails, to many of those so-called common assaults and batteries, frequently on women and on delicate or aged men; and yet the latter offences are altogether too often, both in England and in Australia, visited with a few shillings' fine, whilst the offence of stealing a trifling article is sometimes punished with several months' imprisonment with hard labor. The greatest care and strictest investigation should precede corporal punishment, but when inhuman brutality is clearly established it seems difficult to contend that it is not justifiable.

As an instance of how the fixing of a minimum punishment in an Act of Parliament may bring about injustice I may mention that for the crime of burglary three years is the lowest that can be awarded in South Australia. Judges have no option but to sentence prisoners to that term for entering a publican's cellar through the trapdoor in the street and taking a bottle or two of spirits or ale.

PUNISHMENT OF HABITUAL OFFENDERS.

The next subject to which reference will be made is one of the most difficult with which those who administer the Criminal Law

have to deal, namely, the punishment and treatment of habitual criminals. This question is occupying the attention of many earnest and learned men outside of the judicial arena. One of the most able efforts to solve the difficulty I have seen is the plan proposed in the paper read by Dr. S. A. K. Strahan before the British Association at Cardiff, in August, 1891. Dr. Strahan is apparently well qualified to speak upon it. He is not only a doctor of medicine; he is also a barrister-at-law, and a member of several learned societies. He therefore can and does treat the subject both from its medical and legal aspect. The title of his paper is "Instinctive Criminality: its True Character and Rational Treatment." Few will peruse it without a feeling of astonishment and sadness—astonishment at the mass of facts gathered within so small a compass, and the apparently irresistible scientific deductions to be drawn from them—sadness at the thought that if these deductions are warranted, how many of our kind seem doomed to be criminals. I do not wish to be understood as indorsing such conclusions; I do not pretend to the ability to either refute or support them.

Dr. Strahan confines his remarks to the habitual, or, as he calls him, the "*instinctive criminal*." He says the class referred to as instinctive criminals does not include those who have become criminal from passion, poverty, or temptation, or even from example and education alone. It is composed solely of individuals who take to anti-social ways by instinct or nature, and who murder and steal, and lie and cheat, not because they are driven to do so by force of adverse circumstances, but because they are drawn to such a course by an instinct which is born in them, and which is too strong to be resisted by their weak volitional power had they the desire to resist, which they have not. He adds:—"To this class belong fully two-thirds of our whole criminal population, including offenders of all grades, from the murderer to the petty thief. He says that physically and mentally they are a degenerate class, and quotes statistics of a startling character as to the number of them that are insane, or become so, and on the hereditary transmission of criminal instincts. His extracts from the report laid before the House of Lords in June, 1891, show that there are annually in the United Kingdom a quarter of a million commitments, which are believed to represent only 145,000 individuals, viz., 112,000 men and 33,000 women. Of these 33,000 women, 11,000, or 33 per cent., had ten imprisonments and upwards recorded against them; and of the 112,000 men, 16,250, or 14.5 per cent., had suffered the like number of punishments. Dealing with this report, Lord Herschel said:—"Whether the punishment inflicted was regarded as a deterrent or as a preventive, or for reformatory purpose, these figures showed that the existing system had completely broken down, and was really a disastrous failure." Dr. Strahan admits that upon the criminal from passion

or poverty, and upon the designing person who, after thinking the matter out, elects to run the risks of his action, punitive punishment has a deterrent, and consequently a curative, effect; but he adds that upon the criminal from instinct and upon the habitual drunkard it has no more effect than had the whip and the chain upon the ravings of the maniac of a hundred years ago, and these cruel and impotent agents it must soon follow to the oblivion of the things that were.

The system of treatment that the learned doctor advocates should take the place of the present is prolonged incarceration upon an indefinite sentence in an industrial penitentiary. He thinks that every Judge should be empowered to send any person convicted before him to an indefinite term of incarceration in such penitentiary, provided at least three previous convictions could be proved. In this institution the plank bed and solitary confinement would be unknown. In the place of such treatment every effort would be made to improve the criminal so far as possible morally, physically, and intellectually, and from this place he would be set free on parole only when it was thought that his anti-social instincts had become sufficiently blunted to enable him to mix in society with safety. He adds, finally, that the continued seclusion of the instinctive criminal would very materially limit the production by propagation of this most undesirable class.

The Criminal Law of nearly all, if not of the whole, civilised world, provides that additional punishment may be inflicted upon those previously convicted. It is somewhat singular that the author of "Crimes and Punishments" expressly dissents from this being justifiable. His grounds for doing so he puts as follows:—From the point of view of the public interest, which in theory is the only legal view, it is no mitigation of a crime that it is a first offence, nor any aggravation of one that it is the second. The injury to the public is precisely the same whether the criminal has broken the law for the first time or for the thousandth and first, and to punish a man more severely for his second offence than for his first because he has been punished before is to cast aside all regard for that due proportion between crime and punishment which is, after all, the chief ingredient of retributive justice, and to inflict a penalty often altogether incommensurate with the injury inflicted on the public.

Probably it is such reasoning as this that induces some Judges to ignore previous convictions. It may be safely averred, however, that the great consensus of opinion is that the present law providing for increased punishment after previous convictions is founded on strict justice and common sense. In many instances it would be a relief to society, and the criminal also, if the latter, after being several times convicted, were separated from his kind for the remainder of his life, with the qualification that Dr. Strahan provides as to the possibility of regaining his liberty.

It is from no feeling of antipathy to these men such an opinion is expressed. Cruelty and malice may engender a passing feeling of this nature, but for all ordinary crimes a Judge, with any experience, knows how heavily handicapped the man who has been convicted is in any fresh start in life. He is, in a sense, a marked man. He must almost necessarily assume an *alias*. Under this assumed name he may be fortunate enough to get into a good situation. A friend of his employer recognises him, and at once asks the employer if he knows the sort of man he has in his service, tells of his crime and his assumed name, and the result is his dismissal. It seems hard that his punishment should still go on, but it is difficult to see how his employer's friend could act otherwise. He might remain silent no doubt; but if he did so, and evil results ensued, his friend, hearing that he had concealed the danger, might justly doubt his friendship. The convict, driven from one place to another, at last unable to get anything to do, constantly watched by the police from the day of his release, and apparently an outcast from society, and seeing no prospect of better things, again relapses into crime, and at last is ranked as an habitual. The *aliases* he has been obliged to assume to get employment always tell against him with a jury. Judges often have plaintive stories of this kind before them; some, of course, are concocted, but others are true. For such men, therefore, it seems desirable, for their own sakes as well as that of society, to provide a permanent retreat from their kind, somewhat in the manner suggested by Dr. Strahan.

It will be noticed that Dr. Strahan stipulates that only those who have been three times convicted of an offence should be so segregated. It may be open to doubt if this test would always be the true one. Attention has already been called to the fact that many convicted murderers have their sentences commuted to imprisonment for life, and after a few years are often again cast loose upon society. Under Dr. Strahan's exception such a convict would escape, whilst a poor miserable drunkard, three times convicted, might be sent to the penitentiary for his life. It is the brutal and the malevolent, the burglar, the garotter, and the violent criminal that society is most interested in excluding from its midst, and where the evidence discloses brutality, diabolical ingenuity, or deliberate malice it may justly be urged that it ought to be in the power of the tribunal convicting to order that, after the expiration of a certain term of imprisonment, such offenders should be separated, as Dr. Strahan proposes, notwithstanding there are less than three previous convictions against them. Of course, in such a penitentiary full provision is proposed, and would be necessary, for classifying prisoners. In some form or another each would have to earn a living, and every effort would be made for their moral improvement, and full opportunity given for them to reform. The merely conforming to the rules of the establish-

ment for a given period should not of itself entitle an inmate to his discharge. As a rule, the habitual criminal will earn more good prison marks than the occasional offender. It is a singular phase in the character of the former that their conduct in gaol is almost invariably exemplary, their experience having taught them the necessity of this in order to gain good service time in reduction of their sentences.

It is evident that the subject of the treatment of habitual criminals gives scope for wide difference of opinion, and for far more detail than can here be entered on. The success of Dr. Strahan's, or any similar proposal, will probably depend upon the character of those who would have the custody of the offenders. Rules as unalterable as the laws of the Medes and Persians would have to be enforced with firmness and inflexible justice, and the inauguration of the system would require the assistance of experienced governors of gaols and others accustomed to the charge of convicted men. Dr. Strahan's suggested reform is of deep interest to all thinking men. It is not one to be hurriedly approved or condemned. As a sympathiser with him in the object he has in view, I should like to see it, or something on similar lines, succeed; but it is useless to deny that there are herculean, but not, one may hope, insuperable difficulties to conquer—any half-thought out or imperfect effort would be certain to end in disastrous failure. If Australian federation is to be an accomplished fact in the not remote future, then the difficulty would be much lessened, as a suitable central place within the Federal Territory might be selected to test the feasibility of the reform, and the necessary expenditure incurred at the joint expense of the whole of Australia, and the criminals of each colony might be sent to the penitentiary. At any rate they could federate for this purpose. Dr. Strahan proposes that in England the management of these industrial penitentiaries should follow somewhat on the same lines as the public asylums, viz., by a medical director acting under a committee of magistrates, or of the local county council. In the place of the prison warders there would be a staff of instructors, whose duty it would be to teach the young and ignorant, and to see that the idle and indifferent were employed. He proposes there should be a gymnasium, a library, a band, and a drill sergeant, and, as before mentioned, a strict separation of the very depraved from the rest, with every encouragement for those of the lowest grade to rise step by step to the highest grade, and join those who are qualifying for discharge on parole. He foresees that an outcry against the institution of the indefinite sentence will be raised in England, but points out that these have already been adopted by several of the United States of America (such as New York State, Massachusetts, Ohio, and Pennsylvania), and also calls attention to the fact that it is not the ordinary responsible citizen that is being dealt with. Coming to the question of cost, he says

after the initial expenditure the penitentiaries ought to be soon almost self-supporting. He points out that in England the administration of criminal justice costs the annual sum of seven and a half millions sterling, and adds he has not the slightest doubt that within ten years of the establishment of the new system this vast expenditure might be reduced by a half.

It must not be forgotten in connection with the question of the cost of the proposed penitentiary that the State is already burdened with a heavy tax to support and guard the class of criminals referred to. It would only be a transference of this expenditure to a new and, it is hoped, a more effective department. The only immediate outlay of any magnitude would be the cost of the site, buildings, and necessary surroundings. As before pointed out, this would be a light matter if shared in due proportion by all the colonies. The preceding remarks on the treatment of habitual criminals are intended as suggestions only. They are the result of reflection and study of much that has been written on the subject. The tendency of my own thoughts upon it, before Dr. Strahan's opinions could have been known in Australia, will sufficiently appear by an extract from a previous address I gave before the Australian Natives' Association in Adelaide. It is too long to read to you now. Dr. Strahan's address was delivered on the 25th August, 1891; mine upon the 14th September, 1891. The coincidence seemed sufficiently interesting for me to take the liberty of sending him a copy, and he favored me with one of his pamphlets in return. It is most earnestly written. In the preface he says, "It has been received with most courteous consideration on all hands. The press criticisms have been friendly, not to say flattering, and this notwithstanding the fact that some very radical changes in our present system of dealing with habitual criminals were therein advocated. On the other hand, I have received a host of letters from prison surgeons, criminal lawyers, medical practitioners, and others, all of which more or less strongly support the views I ventured to advance, and not a few of which indorse my conclusions *in toto*."

I am not aware whether any subsequent efforts have been put forth to give the learned doctor's advocacy a practical test, but if the trend of English feeling is so strong in his favor I should think he is not the man (judging from the tone of his address, for I have not the privilege of his acquaintance) to let the opportunity pass.

PREVIOUS CONVICTIONS IN OTHER COLONIES.

There is one other matter in connection with the habitual criminal which might with advantage be provided for by legislation. Authority should be given to the Judge passing sentence to treat convictions in any of the adjacent colonies as "previous convictions," entitling such Judge to award the additional punishment

provided by law against an habitual offender. Each of the colonies is subject to periodical visits from members of the criminal class, and it is important that ample power should be given to treat them according to their desert. It is almost a burlesque of justice to punish a man who has perhaps a score of convictions against him in another part of Australia as if he were a first offender. Federated Australia would probably render such an anomaly impossible.

INEQUALITY OF PUNISHMENTS.

The last portion of the subject to which time permits reference is that of the inequality of punishments by the different Judges. It is often asserted that punishment varies according to the idiosyncrasy of the presiding Judge; and certainly it is scarcely possible to imagine a wider divergence of opinion upon this point than, say, between the Recorder of Liverpool (Mr. Hopwood, the great exponent of light sentences) and Sir J. Fitzjames Stephen. The latter would probably give as many years' punishment as the former would months' for the same offence. The subject is well dealt with in a recent issue of "The New Review," by Mr. Justice Hawkins, Mr. Hopwood, and by Mr. H. B. Poland, an eminent criminal lawyer. I do not think it possible to put the difficulties of the subject in a better light from every point of view than these articles exhibit. Beccaria was of opinion that a short simple code with every punishment attached to every offence, with every motive for aggravation of punishment stated, and on so moderate a scale that no discretion for its mitigation should be necessary, would be the means best calculated to give the penal laws their utmost value as preventives of crime. Mr. Poland's practical experience shows that, however excellent Beccaria's theory, it would be impossible to carry it out in practice.

Previous to 1846 it was customary in Acts of Parliament to fix the absolute and minimum punishment. This was found to so often work injustice that it was abolished.

Mr. Poland's paper shows how impracticable it is to lay down any rules so as to prevent sentences being unequal. Taking the two crimes of manslaughter and perjury as illustrations, he says:—"Manslaughter may be next door to murder, or not far removed from an accident. Perjury may be perjury to convict an innocent man of murder, or perjury to hide a fault or crime committed many years ago, or committed to screen the fault of a near relative, or to save the character of a woman." Clearly if the same sentences were given in the respective cases Mr. Poland mentioned the gravest injustice would be done. It would not be tolerated in any community of free men.

In passing it may be well to bear in mind that the actual carrying out of a sentence, if it is deemed excessive, can always be prevented by the exercise of the prerogative of mercy, so that the

danger of any arbitrary or cruel punishment is more imaginary than real. Nevertheless, if it were possible it would be better to prevent error rather than cure it.

Mr. Justice Hawkins contends that the inequality of sentences will never cease until some general leading principles to be observed in awarding punishment are authoritatively laid down for the guidance of the court, and suggests a joint commission of lawyers and laymen for the purpose of framing such a code. He does not approve of the proposed court of criminal appeal. Mr. Poland does not think the present system can be altered with advantage, and remarks that Judges and Magistrates now generally consider that the *certainty* of punishment is of more consequence than the severity. He seems to think that to

Fill the seats of Justice
With good men, not so absolute in goodness
As to forget what human frailty is,

is all that is required in England.

My own view is that much assistance might be obtained from such a commission as that proposed by Mr. Justice Hawkins, so long as the result of its deliberations left the Judges sufficient latitude to deal with exceptional cases, for which in the nature of things it seems impossible to provide. The First Offenders Act is an admirable provision, with the power it gives to refrain from punishing and to release the accused upon recognisances. It is a statutory declaration by the Legislature as to the spirit in which first offences should be dealt with. If Dr. Strahan's proposal, or anything approaching to it, becomes law, there will be little difficulty in knowing what sentence to award the habitual criminal—the most troublesome of all. It is much easier to deal with the occasional or accidental criminal. In proportion as education advances—and, to my mind, the spread of education means the diminution of crime—men's minds become enlarged, and their sensibility increases. It has been justly said that punishment "must be according to the spirit of the age." We have read what punishment of criminals meant in a less enlightened age. The retrospect is a dismal, if not a humiliating one. Great and relentless severity failed to cure the evil. Under more benign laws it has decreased, and is generally far less important than it formerly was. Nevertheless, it is necessary to avoid the substitution of an exaggerated or misplaced sympathy for discriminating and properly calculated severity; in other words, punishment should be just and not vindictive, its certainty being of far greater importance than its severity.

9.—BIMETALLISM.

By D. MURRAY.

“Bimetallism” and “bimetallists” are terms of recent date. Before the year 1873 the names as well as the signification were almost unknown. Their introduction, however, did not denote a new science. The theory and practice were for centuries in existence. But in England gold monometallism, existing since 1816, operated in harmony with the joint standard on the Continent and in America. This fostered the idea that, independent of silver, gold sufficed for all purposes of the currency. People did not believe that the demonetisation of silver would affect its price. The ratio of 1 to $15\frac{1}{2}$ was expected to continue, though silver as a legal tender was proscribed. The delusion that the gold standard was in some way connected with the national prosperity kept fast hold of the national mind. England looked on with a feeling of self-sufficient pride while other nations were satisfied with their combined standards, as in the case of the Latin Union, and Germany took advantage of her opportunity in the payment of a large war indemnity to follow British example in exchanging silver for gold. The power of a ratio existing under legal enactment and upheld by the free coinage of both metals was not appreciated; there was a general belief that the all-powerful economic influence of supply and demand somehow maintained the equilibrium. It was either forgotten or ignored that being constituted legal tender the demand for the precious metals for currency rendered their exchange value much higher than it otherwise would have been if used for merely economic purposes. It was said that if one metal got too plentiful a demand sprung up for it in those countries which principally used it, so that the balance was maintained. That a fall in the value of silver unprecedented in history should take place was thought impossible. In former times had not silver been produced in quantities three times greater in proportion to gold than at that period? And in the twenty years immediately preceding 1873 had not the production of gold doubled that of silver? So great indeed was the increase that fears were entertained of its stability, and under the influence of these fears Holland actually adopted a silver standard. Yet the ratio never varied to an appreciable extent. The *agio* was limited to the mere cost of transfer and insurance. If silver was cheaper in England the gold of France was at hand to buy it, and *vice versa*, for England was still the principal market for silver. Thus, by a simple law, restated in the French enactment of the year 1803, the *par* of exchange between silver and gold remained unbroken for two centuries, though enormous variations in the yield of the two metals frequently occurred. The law is embodied in the three following clauses:—

1. The mints to be open to the coinage of all gold and silver brought to them.

2. The gold and silver to be coined into legal tender money. The quantity of pure silver in the silver coins to bear such proportion to the quantity of pure gold in the gold coins as may be agreed upon by the high contracting powers.
3. The debtor, saving any previous stipulation to the contrary, to have the right to pay his debts in coins of either metal, at his pleasure.

RESULT.

One result of the complications which have arisen in consequence of the demonetisation of silver is that the subject, in the aspect of the sufficiency of the currency, is now attracting a large share of public attention. Economists have furnished the world with treatises on money, on banking, on wealth and capital. The operations and the instruments of credit, and their dependence on the basis of the metallic currency, have all been handled; but except by a few men, who have been described as doctrinaires and visionaries, the dangers arising from the demonetisation of silver have not been discussed or realised. Even such well-known economists as Jevon and Bagehot, from whose theories bimetallists draw their most convincing arguments, shrank from adopting the conclusions to which those theories led up, and gave it as their opinion that the probability of a rise in the purchasing power of gold was a matter of speculation. Both believed that the transient recovery that silver made in 1876 was a sign of a permanent turn of the tide, so little did they realise the momentous character of the fall in values which from small beginnings has already reached a divergence of 40 per cent.

The advocates of bimetallism are no longer thought visionaries. The subject has taken hold of the minds of the best thinkers in Europe; some of our ablest statesmen are its advocates. The chambers of commerce throughout Great Britain agitate for its adoption, and the people generally, from the highest to the lowest, alarmed at the persistent depreciation of all commodities, are preparing to demand the only solution yet presented to their view.

EFFECTS OF DEMONETISATION.

We have witnessed during the past twenty years a gradual and continuous decline in the price of silver. During the same period the price of commodities generally has declined as continuously, and persistently; and as unaccountably, except on the ground above stated.

The declines in silver and commodities have been simultaneous, and almost to a like extent. At the commencement of the present year the price of silver was 3s. 3d. per ounce, commodities, according to the most reliable statistics and the indices of the economic journals, having fallen 30 per cent.—an equivalent ratio

in regard to gold. This divergence, because of its uniformity, can scarcely be attributed to a variety of causes, but must be the result of some single action which affects all commodities in the same way and at the same time. The operation of this action must either be on silver and other commodities to reduce their value, or on gold to enhance its value. To suppose that both have been affected in different directions may still further complicate the question, but does not alter the direction of our search. The usual causes of a fall in the price of any commodity are increased facility of production, over-production, or a decreased demand, but these causes, from their very nature, do not affect commodities simultaneously, nor are they such as would operate continuously, nor are they all, as a rule, disadvantageous to the producer. The cheapening of any article of consumption from increased facility of production is beneficial to all—producer, consumer, and worker. Over-production, applying the term to all commodities, is an economic impossibility, and a universal decreased demand means only a decreased power to purchase, which is the result rather than the cause of any widespread depression. We are, therefore, driven to the conclusion that gold, as the sole measure of the value of other commodities, has had its worth enhanced, and the question arises, has the action of 1873, in the demonetisation of silver, had the effect of so raising its value that its purchasing power in regard to all exchangeable merchandise has been increased? Before replying to the question we must refer to one feature in regard to the precious metals which distinguishes them from other commodities. Their volume is the accumulation of centuries, and the annual supply does not materially increase or diminish it. Therefore the exchangeable value of money and commodities is not appreciably affected by the usual variations in the supply of the currency, and, unless such a change be abnormal, its stability is unaffected. The inquiry resolves itself into two questions—Has there been any extraordinary decrease in the volume of the currency, or any abnormal and continuously increased demand for it? The latter question, I think, we can answer in the negative, as far as activity in trade and commerce is concerned, but on other grounds, presently to be noted, there has been an unusual demand. To the first question we reply there has been an enormous decrease in the volume of the currency. Before 1873 the world's currency consisted of about £800,000,000 of gold and an equal quantity of silver, which in times of commotion was supplemented by the large accumulation of both metals in private possession. Both stores were available for currency purposes, both formed the basis on which the vast structure of commercial credit was erected. But when silver was demonetised in Germany, and free coinage suspended over the rest of Europe and America, gold alone had to perform the function which both had hitherto fulfilled in all international exchanges, and as the measure of value of all commo-

ties. The scarcity of gold prevents it taking the place of silver in the internal exchanges of European countries, but silver has now become a mere token, having no relation to its actual value; and its volume, because of fluctuation in price, cannot be used as a store of value. I think, therefore, that the diminution in the volume of the currency is thus sufficiently proved. On the other hand, the annual augmentation of the world's store of gold has been more than absorbed by the nations which have recently adopted the gold standard. Germany, Holland, America, Italy, Austria, Scandinavia, have between them absorbed something like £250,000,000, so that the stocks in the other gold-using nations have actually diminished, while the recent adoption of the gold standard in India will further increase the drain. The law of supply and demand thus manifests its power in regard to the currency. While silver and gold were united the artificial demand for currency purposes, owing to those metals being the sole legal tender, raised their value beyond their economic worth, gave them a monopoly, and hence assisted their accumulation. The rupture of the ratio and demonetisation of silver have conferred the entire currency monopoly on gold. The currency supply is decreased, and the demand for it increased; hence its appreciation.

The every-day aspect of this appreciation of gold is the reduced price of all commodities, as well as of silver; and we are led to the belief that an increase of the currency by the rehabilitation of silver under some fixed ratio will have the effect of restoring, to a large extent, the equilibrium which previously existed; and for this reason, believing not only in the possibility, but also in the safety of the proposed expedient, bimetallists seek to urge on the English Government a reconsideration of the entire question.

HISTORIC PARALLEL.

To satisfy ourselves that an expansion or contraction of the currency have always been accompanied by similar results we have only to recall various periods in past history, marked either on the one hand by unwonted development and prosperity, or on the other by depression, want of employment, and poverty, and we shall see how these conditions coincide with, and apparently result from, an increase or diminution in the supply of the precious metals.

In the 16th century, after the discovery of America had laid open to the Spaniard the riches of the Western Continent, the large influx of silver into Europe gave an impetus to trade and commerce, which reacted on the value of all commodities, raised the wages of the laborer and artisan 300 per cent., and increased the price of land fourfold. Again, in the period between 1780 and 1810, the production of silver underwent a marked increase, and prosperous times followed in its wake. Following these good times came the change to the single gold standard in England in

the year 1816, and along with it a falling off in the yield of both gold and silver. Its results I will give in the words of Alison, the historian—"The effects of this sudden and prodigious contraction of the currency were soon apparent, and they rendered the following years a period of ceaseless distress and suffering in the British Isles." This period of depression and restricted currency, now and then temporarily relieved by gleams of better times, continued till the middle of the century. The gold discoveries of California and Australia then opened up a new era of prosperity and progress. From an average of £10,000,000 annually the supply of the precious metals rose to £35,000,000. Contracted currency and low prices and poverty vanished together. We are all cognizant of the tide of prosperity which then overflowed Europe, carrying advancement in every department of human life. Commerce, manufactures, science, arts, all partook of the general progress, which for twenty years showed no sign of abatement. There were, we all know, during these years, several financial panics, but these were the excrescences of our inflated credit system improperly used in the speculative mania which prosperous times foster. The rapid recovery in the amount of business and in the prices of commodities proved that other causes than a diminution of the currency were at work. It is sufficient for our purpose to note that prices were maintained throughout the entire period, and at no time were prospects brighter nor the hopes of a continuation of prosperity more likely to be verified than in 1873, when the demonetisation of silver in Germany and America came like a blight to wither these hopes, and to inaugurate a period of decline more persistent and more depressing in all its aspects than any which preceded it. Prices of all merchandise have fallen to a lower level than that preceding 1850. Want of employment and destitution among the working classes are as accentuated as they were then, and both industrial and financial stagnation marks its effects in the destruction of capital and depreciation of securities.

INADEQUATE CAUSES.

It may seem strange that now, as well as in previous depressions, all sorts of causes other than that now indicated, were credited with the result. Their variety is only equalled by the lack of argument in support of their claims. Over-production is the never-failing jack-in-the-box, springing up on all occasions. It suits the mind of dealers in one commodity, and admits of illustration in individual instances. We ask what becomes of the over-production? By the end of one year we are ready for another year's produce! Why are the indigent, the underfed, and underclothed so deplorably on the increase? Over-production in individual industries works its own cure in the course of a year from economic causes, but we are asked to believe in a continuous, senseless, and ruinous over-production at a time when all industries are languishing, and a large

percentage of workers are unemployed. Absurdity in argument can surely go no further. Speculation and over-trading are next set forth as the originating cause of the depression, and, because in some of our commercial panics they have been chiefly instrumental in precipitating the catastrophe, there is some reason in attributing it to this source. In these colonies especially this has been the case, as the inflated land speculations had the effect of first concealing, and afterwards, in their collapse, accentuating the approaching crisis. That crisis, nevertheless, as surely though perhaps less rapidly would have overtaken us. The depreciation of all securities, and of all our staples, when measured by gold could not therefore fail to disturb the stability of financial institutions whose liabilities were payable in gold.

Countries dependent for their development on the expenditure of foreign capital are sure to feel the pressure first, as well as most acutely. While the producers and manufacturers and land-owners of Europe are suffering from the low price of their produce, we, who depend altogether on the profitable export of our staples, cannot fail to suffer in a higher degree. Numerous other causes have been advanced to account for the depression, such as competition, labor agitations, strikes, high rents, misuse of land, inflation of credit, and the like; but all of them are more the result than the cause, and individually they have existed in good times without producing any injurious result.

WARNING.

We have said that some economists of note have opposed a return to bimetallism because they disbelieve the result to which their own theories of the currency must have led them. Others, however, such as Seyd, Wolowski, Lavaleye, boldly proclaimed their conclusions that the result of the disruption of the standard would be disastrous in every sphere of industry. But to conservative England theirs was as "the voice crying in the wilderness"; practical men of business, financiers, paid little attention to the warning. It sounded too theoretical for them. The report of the 'Bankers' Union of Paris says—"Their abstention from it is a matter for regret, and it is high time that agriculturists, bankers, merchants, and tradesmen, should take part in the discussion." Their action alone will be able to command the attention of our legislators, and to bring into the sphere of practical politics that which has been too long an academic question. It is still maintained by the advocates of gold monometallism that owing to the improved modes of transacting business, through banking facilities, the extension of note circulation, and in consequence of the innumerable instruments of credit now in use, the necessity for a large supply of a metallic currency is done away with, and that as time goes on these instruments will still further supersede its use. Facts, however, do not favor these conclusions. The demand for

gold was never so great as it now is; and its increased value is represented by the larger amount of commodities offered for it. As a measure of value and a medium of exchange it is wanted in all places where there is wealth to measure and merchandise to exchange. It is the basis of every instrument of credit and must exist in sufficient quantity to uphold credit. The issue of notes unrepresented by a store of bullion or specie is limited in most of the European States to a comparatively small amount, and even this is represented by securities easily convertible. An inconvertible currency is the last resort in national financing, and the communities on which it is inflicted are either in the throes of some national commotion, or have not yet fully emerged from the domain of barbarism.

The security of our vast credit system is based on the presumption that each individual instrument has awaiting it, at the option of the holder, its equivalent in coin; and the danger lies in the possibility of a doubt of the sufficiency of this supply of value entering the public mind. Economists agree that bills of exchange as credit instruments do not at all supersede the use of money, as its presence is presupposed at either end of each transaction. Therefore the fluctuation of the bank reserves are watched with feverish anxiety, and the rapid advance of the bank rate on a moderate withdrawal of gold attests its paramount interest.

PROPORTION OF CURRENCY TO WEALTH.

It is significant of the novelty of the situation that economists have not tried to solve the question of a mathematical ratio between the amount of the metallic currency of a country and the measurable wealth contained in it. Jevon, in his book on money, admits that there is some such ratio, but in the concluding chapter of his work he refers to the inquiry as indicating a question as to the "degree of civilisation, of Providence, or of complexity of banking organisation" rather than as affecting the important question of a sufficient or insufficient currency.

The want of interest in this question arose, no doubt, from the fact that, while the combined standard existed, the aggregate volume of both metals in their monetary use being the common possession of the nations, any increase depended on the discovery of new sources of supply, and it was not supposed that the demonetisation of one of them would involve a reduction of the currency and the enhancement of the exchange value of the other.

THE FUNCTIONS OF MONEY.

In order properly to understand the question it is necessary to obtain a correct estimate of the different functions which money fulfils. A common mistake is made in attributing a low rate of interest to an abundant currency. The ordinary fluctuations in the bank rate of discount only indicate a larger or smaller amount

offering on loan, but the amount of the world's currency cannot fluctuate in this way. Those who connect cheap money with an abundant currency are not the best able to see that the same cheapness of money in the open market may be the result of stagnation in trade caused by an insufficient currency. It therefore helps our inquiry if we are able to see clearly how money may be plentiful and cheap in times of depression and bad trade, while really in another and its most important aspect it is deficient and dear, and that both conditions may exist at the one time—that even one condition may be a consequence of the other. Professor Jevon, in the work already referred to, attributes to money at least four functions—a standard of value, a medium of exchange, a common measure of value, and a store of value—and asserts that it is important to discriminate between them in estimating the results of monetary action. The choice of the precious metals as the depository of these functions was made early in the world's history, and from their unique qualities they are still considered the fittest of all commodities to perform the duties laid upon them.

As a standard of value we recognise that stability must be its essential feature. This stability is not so much dependent on the amount of the annual production of the precious metal (which is insignificant compared with the accumulated volume) as on the proportion which that volume bears to the volume of commodities it has to measure. This second function of money—a measure of value—has also its essential feature, which we consider to be its volume, and on which depends to a large extent the stability of the standard. In its function of a medium of exchange and store of value we recognise the importance of its general diffusion, its adaptability to all mercantile purposes, and its facility of transport—qualities which make the combined gold and silver currencies the best of all known agencies for the transaction of business.

The currency of the world is at all times the measure of its commodities, and its store has a tendency to diffuse itself according as there are commodities to measure. Any general increase of commodities without a corresponding increase in the measure reduces prices, and a decrease in the quantity of the measure will have the same effect, or, to put it into common language, when money is abundant prices rise and trade is good; when money is scarce there is a falling market and bad trade. When, therefore, by any instrumentality the relative proportion of the currency on the one hand and commodities on the other is changed prices are disturbed, and a rise or fall takes place. In the case of a diminishing currency producing lower prices the effect on trade and commerce is at once apparent. The producer suffers in profit. This he may attempt to rectify by increasing his production, so as to have the smaller margin over the increased output. This he speedily finds to be delusive, as the same amount of money has to measure the increased amount of merchandise. If the purchasing

power remains the same his efforts to increase production result in further loss. Another mode of restoring profits is now tried—he must cheapen the cost of production. The reduced value of all his appliances and raw material assist him in this, but as labor is the principal factor in production a reduction in its cost becomes imperative. He is then brought face to face with the most unhappy feature in a producer's experience—a conflict of capital with labor; and at this point, springing from the same cause, the sufferings of the wage-earner begin. Thus loss of profit, contraction of business, commercial failures, lower wages, want of employment, destitution, all follow in the wake of a diminution of the currency. But this contraction of production sets free capital. The possessors of money will not invest it in commerce or manufactures because of its unproductiveness. A temporary use for it is sought in the exchange. Instead of now fulfilling the function of a measure of value in the ordinary avenues of trade and commerce it is used as a medium of exchange, and at the very time it is so used transactions are fewer, trade is quiet, and money competes with money for what business there is. In the exchange market it becomes cheap and plentiful. The bank rate of discount abnormally falls. All this time every industry is languishing on account of its restriction. The action of Germany and France in 1873 in demonetising silver had the effect of reducing the currency. Its use as legal tender in international transactions was hampered. The entire burden of the world's transactions was being thrown on gold as the sole measure of value, and its insufficiency in that capacity was quickly proved. Prices at once began to fall, and have continued falling as the influence of demonetisation became more apparent. Now, twenty years after the event, we have not touched bottom. The full significance of the break of the standard has not yet been realised just because silver still has to serve in the internal currencies of the nations, but daily the difficulty of the position is becoming more acute. The uncertainty of the silver standard is such that the tendency to extend the function of gold as the sole standard throughout the world becomes more apparent, the consequent scramble for it accentuated, and its continued appreciation all but assured.

THE MEDIUM OF EXCHANGE.

The effects of the demonetisation of silver on the world's exchange is no less apparent than its influence on prices. Before the year 1873, when silver and gold were linked together under the ratio of $15\frac{1}{2}$ to 1 in Europe and 16 to 1 in America, with free coinage at all the national mints, international trade was carried on with the smallest amount of risk. The movements of the precious metals were assured and caused no uneasiness. If silver or gold were wanted in any country, the means of procuring it were at hand. The agio on either metal was never more than the cost of

freight and insurance, for with free coinage of silver in France no one would part with it in England for less than he could get by sending it to France to be minted, having there the option of exchange for gold at rated value. Germany had also her silver currency, and was to some extent the counterpoise in the European exchanges to monometallic England. But it was in the trade with India that the power of the ratio was chiefly felt. While the rupee was valued at two shillings trade with England was carried on to mutual advantage. The development of its vast territory, by means of railways and irrigation works, as well as by the formation of remunerative private enterprises, was achieved by the introduction of English capital.

Since the change was effected everything has been altered. Gold being now the only medium of exchange, the nations make every effort to obtain it and to prevent its export, and a demand for it in any quarter at once affects the bank rate.

Germany, at the conclusion of the Franco-German war, secured £40,000,000 to £50,000,000 for her new currency, but since 1887 has been unable to make further purchases, and silver, as a token at par value, still circulates throughout the country. Austria and Italy wait their time to complete a gold currency, but dare not now make the sacrifice. India, after holding out all these years with her silver standard, has been obliged to succumb to the strain upon her resources. Year by year, in spite of additional taxation, the fall in the exchange value of the rupee exhausted her coffers, and had it not been that her internal trade under the ægis of the silver standard, and through the stimulus of the improvements made before the change, had been highly profitable, the action which now has been forced on its Government would have been anticipated by many years. It is yet impossible to foresee the result of this action. That it must be momentous for India there cannot be a doubt.

Alison, in his European history, says that the disruption of the old Roman Empire was the effect of a deficient currency more than of moral and social degeneracy. Some time must elapse before the connection between the rated rupee and the altered price of commodities is realised, but a change detrimental to the interests of the natives, caused by Government action, may excite a feeling of discontent difficult to allay. Nor is India alone affected. The disturbance has created a commotion in America, and legislative action of a drastic character may be speedily looked for. That things can go on in their present condition cannot be expected, and people wait with suspense the next movement in the embroglio.

There is at present in Europe and America about £400,000,000 in silver currency maintained at a fictitious value as token money at a ratio value of $15\frac{1}{2}$ to 1, and about half as much in India, also now token money, at a ratio value of 24 to 1. We have

the empire of China and Eastern Asia still with their silver standard, but of uncertain exchange value; so that all over the world the metal is now like the mercury in the barometer, amenable to the influence of every financial breeze. When this state of confusion in the world's currencies will come to an end it is impossible to determine; nor is it possible to gauge the extent to which depreciation of silver as well as of every other commodity will proceed. Each new adoption of the gold standard occasions a new demand for the metal, raises its value, and gives a fresh incentive to hoarding. Already, if it be true, as Soetbeer says, that £12,000,000 annually is absorbed in the mechanical arts, the remaining supply is insufficient to recoup the old currencies, independent of what is required for the new; how can we then avoid the fear of a scramble for gold such as has never before been witnessed? All the time the Parliament of England, engrossed in its Home Rule conflict, is overlooking a tyranny greater than ever oppressed Ireland—the tyranny of gold, upheld by the plutocratic minority, which is destroying the energies and sapping the life's blood of the nation, and bids fair to precipitate a catastrophe which it will require all her power to avert.

COMMERCIAL CRISES.

The depression now affecting all classes of the industrial community we attribute to a deficient currency. It is not, however, to be placed in the same category as the occasional financial panics which have swept over Europe, bringing in their train financial disaster and a temporary paralysis of trade and commerce. These are not the effect of a contraction of the currency, but a result of the misuse of our highly-organised credit system, which in ordinary times is conducive to the economic working of the vast industrial machinery. By means of notes, bills of exchange, and the other numerous instruments of credit the metallic base of our financial system is so conserved that actual cash transactions are rare, and the use of coin is principally confined to retail trading, with occasional transfers of large sums to settle the balances of exchange. The Bank of England has a coin reserve of about £25,000,000, and the other city and provincial banks an additional £20,000,000, while it is estimated that not more than £100,000,000 of gold exists in the country, and on this amount is based transactions to the enormous total of over £100,000,000 weekly; such is the confidence inspired by our credit system and the belief that coin, if required for any of the daily transactions, would be forthcoming. There are occasions when the demand for gold becomes abnormal; these follow in the rear of speculation, and might arise when the currency for ordinary purposes is unusually abundant. For instance, during the great inflow of gold from California and Australia two very severe panics occurred. The prices of commodities under the stimulus of good trade had advanced considerably; periods of

speculation ensued. Speculators sought to realise a profit on the purchase and re-sale of all sorts of merchandise. Manufacturers and producers no doubt were stimulated to their utmost at the same time, but production and manufacture are not doubled in a day. Progress is very slow compared with the increase of speculative transactions. A cargo of imported produce, for instance, is usually transferred from the importer through the agency of the middleman into the hands of the distributor, but in speculative times the same cargo may pass through the hands of half a dozen different purchasers, each sharing a profit, each making use of instruments of credit to finance his operations, and so the pressure on the credit system becomes severe. The bank rate begins to rise, renewals and even discounts are declined, and money becomes almost unobtainable. Meantime the increased price of the merchandise deters purchasers, prices fall, the necessity to realise becomes urgent. The bottom tumbles out of the market and, like a house of cards, the whole speculative fabric collapses, leaving stranded wrecks in all directions, and secret sufferers innumerable. But in an incredibly short time the strain is removed; money again flows in its accustomed channels; the over-production, to which many attribute the crisis, has somehow vanished; the goods have gone into consumption, and prices have regained their former level. It is well known that, notwithstanding the recurrence of these panics, the price of commodities was in 1873 nearly as high as during the palmiest days of the influx of Australian gold, and, in spite of inflations, panics, and the rumors of over-production, the level of prices was maintained and the general prosperity unabated. Since that date, marked by the demonetisation of silver, prices have gone down gradually and surely. The law which upheld the ratio, that is, the free coinage of silver and gold at $15\frac{1}{2}$ of the former to 1 of the latter, was abrogated, and silver took its place among commodities to be purchased with gold, the sole legal tender; and, only that the currencies of the Continent and of America still required it as gold was not available to take its place, the fall would have been still more rapid. As a commodity its gold price maintained a level with that of other commodities; as it fell everything else purchased with gold fell in proportion. The general movement indicated one active cause, to which no other name has yet been given than the appreciation of gold. I have already attempted to show how a restricted currency in its function of a measure of value must tend to reduce prices. I have pointed out that the fall which has taken place, and which is still continuing, in the price of all merchandise and of real estate—a fall in which the laborer is now participating, through the reduction of wages and dearth of employment—is attributable to this restriction. But the public, through the Government, is also made to suffer in proportion to their indebtedness. England, probably the least burdened in this

respect, has repaid about £100,000,000 of her debt within the last twenty years, but now actually has to draw from her people 20 per cent. more of the produce of their industry than when the debt stood at the higher amount. It is not to be wondered at that a powerful section of the community now seeks to let its voice be heard in behalf of a change in our financial system. It is rather surprising that action has been so long delayed. The conservative character of the national mind, the mistaken estimate of the superior utility of gold, and, above all, the selfish grasping of money-lending capitalists, who see in the advance of gold an unearned increment to their wealth, and who hide their cupidity under the delusive cry of cheap bread for the people, and have endeavored to heap ridicule on the heads of bimetallists, in place of meeting them with sound argument, these have hitherto been able to delay the movement in favor of a return to the combined standard, and the intricate nature of the currency question has retarded its advocacy amongst the large section of the community, who prefer to let others think for them, and rely more on assertion than argument. The labor leaders have, as a rule, until lately, held aloof from the movement, no doubt under the conviction that wages paid in gold, under an appreciating standard, is equivalent to a rise. But the stern lessons of the past few years have led them to see that their welfare is bound up in the general prosperity of the country, and that full employment and good wages only accompany prosperous trade and commerce. The labor unions in England are now largely members of the Bimetallic League.

CONDITION OF THE COLONIES.

If England, owing to its immense accumulated wealth, and to her foreign investments, from which she is receiving the interest in enhanced gold values, suffers on that account less than other communities, her colonies, in this respect being borrowers, have had their burdens largely increased. Having to prosecute their industries by the aid of foreign capital, their indebtedness, public and private, is greater per head of the population than that of any people under the sun. The question, therefore, is to them of paramount interest; yet they are scarcely alive to it. The fallacy that, as large producers of gold, their interest lay in maintaining the gold standard held sway during all these years. They have now to realise the enormously preponderating interest which attaches to their production of wool, wheat, silver, and copper. The export of gold for the whole of Australasia, amounting to the sum of £6,000,000 sterling, has no doubt been exchangeable for an increasing amount of imports, but to counterbalance this the other staple exports to the value of £46,000,000 have been subject to an annual depreciation, and, as interest on our debt has to be paid in gold, it follows that the proportion of exports required for the discharge of interest is ever on the increase. The standard on

which our debts were contracted is gold, not that we want gold, but the materials necessary for local development—for railways, waterworks, bridges, wharves, buildings, and for the supply of the numerous private requirements—can only be purchased with gold. The standard has appreciated nearly 50 per cent., and at its appreciated purchasing power we have to value our produce, which requires to be exported to meet interest and principal.

I have annexed an extract of the imports, exports, debt, and revenue of the four principal colonies of Australia to show how the increased quantity of our exportable staples absorbed in payment of fixed charges lessens our exchangeable surplus and reduces our wealth-producing capabilities.

I have compared two periods, each of three years, the first from 1873 to 1877, the second 1887 to 1891, and also the year 1892—

1873-7.

Tonnage	tons, 5,021,835	=	3 tons	per head
Imports	£36,794,000	=	£21 5 0	“
Exports	£36,909,000	=	£20 14 0	“
Public debt	£35,483,000	=	£20 10 0	“
Public revenue.....	£11,173,000	=	£6 8 0	“
Population.....	1,730,000			

1887-91.

Tonnage	tons, 12,382,850	=	4½ tons	per head
Imports	£57,312,000	=	£20 0 0	“
Exports	£50,784,000	=	£17 10 0	“
Public debt	£130,024,000	=	£45 0 0	“
Public revenue.....	£21,115,000	=	£7 6 0	“
Population.....	2,888,000			

1892.

Tonnage	tons, 13,459,129	=	4½ tons	per head
Imports	£49,728,904	=	£15 19 0	“
Exports	£53,176,740	=	£17 0 0	“
Public debt	£152,521,117	=	£48 18 8	“
Public revenue.....	£24,308,477	=	£7 12 9	“
Population.....	3,117,441			

For the first period the interest on public debt at 4 per cent. . .	£1,400,000
“ “ “ private liabilities, say . . .	£1,400,000

Making a total interest payment of..... £2,800,000
(Being one-thirteenth of the value of exports).

For the second period the interest on public debt at 4 per cent. . .	£5,200,951
“ “ “ private liabilities	£5,200,951

Making a total interest payment of..... £10,401,902
(Being one-fifth of the value of exports).

For the year 1892 the interest on the public debt at 4 per cent . .	£6,100,844
“ “ “ private liabilities	£6,100,844

Making a total interest payment of £12,201,688
(Being nearly one-fourth of the value of exports).

While in the first five years since 1873 one-thirteenth part of our exports sufficed to pay interest on our indebtedness, in the last five

years ending 1891 it required one-fifth of our exports to cover the corresponding liability; but for the year 1892, the statistics of which are lately published, the comparison is still more alarming, for out of a total export of £53,176,740 an amount of £12,206,660 was payable in interest, or very little less than one-fourth of the entire amount. It is important to note that, while the gold value of the exports declined in the second term of five years to £17 10s. per head of the population, from £20 14s. in the first term, and still further to £17 in 1892, the productive capabilities of the colonies, as manifested in the tonnage returns, were increased—the average tonnage in the first period being under three tons per head of the population, and about four and a half tons during the second period. Thus, while the money borrowed was to a large extent spent in railways and other reproductive works, which did increase the produce of the colonies, as illustrated by the shipping returns, to the extent of over one-third, the money value of their production has been reduced to the extent of nearly one-fifth per head of the population.

Indications of the strain of these increasing burdens on the resources of the colony have not been wanting in past years. The increase in our Customs duties, the additions to direct taxes, the efforts at retrenchment of public expenditure, are all signs of its presence, and the future looms with more duties, more taxes, more retrenchment. We have before us the fate of the goose that laid the golden eggs. The overburdening of industries will speedily result in their destruction, and our Governments will be brought face to face with a deficit that will paralyse them. The financial institutions of the country have already come under the Nemesis. Men of business who will not recognise the cause blame their institutions for reckless borrowing and more reckless lending, and general mismanagement. These accusations only follow the collapse. The same men who indulge in these strictures may have been directing these institutions during prosperous years. Our banking probably has been rash because it was prosperous, but the cause of the fatality lies much deeper than any actual mismanagement. The depreciated gold price of all securities, owing to the reduced value of their produce, is the overpowering cause. Had our wool and wheat maintained their former price, these securities would have been full value and saleable. We argue from this that no reconstruction without revival in values can assure stability of our financial institutions. By capitalising liabilities the burden is shared by the creditors, but the Nemesis is still over every undertaking, and the increasing gold appreciation sinks them still deeper in the mire. The further progress of depreciation depends altogether upon how soon the equilibrium between gold and commodities is established. If, as we still see, the drain upon the volume of gold for the use of new currencies continues, the process of depreciation must also continue, and our

means of defraying liabilities must proportionably decrease. These Governments have a voice in the counsels of the mother-country—let them exert their influence. Let them say to creditor England—We must by some means be released from this strain; we demand your attention to the currency question; its increase by means of the remonetisation of silver gives promise of relief, and your present apathy and inaction is irritating to us, and may eventually bring us into the condition of inability and unwillingness any longer to bear the intolerable burden.



Section H.

ENGINEERING AND ARCHITECTURE.

1.—WIND PRESSURE.

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In order that bridges, viaducts, chimney shafts, towers, elevated water tanks, roofs, and other structures of an engineering nature may be scientifically designed and the opposite evils of weakness and undue expense both avoided, it is necessary that all forces acting upon them should be known within a comparatively narrow margin of error. As far as vertical forces are concerned this condition is in all ordinary cases satisfactorily complied with. The weight of the bridge, viaduct, chimney, tower, tank, or roof, and also that of the railway train, crowd of people, or mass of water, constituting what is usually called the live load, can be, and is usually, determined with a maximum error of not more than 1 or 2 per cent. With regard, however, to the horizontal forces due to that ubiquitous agent, the wind, and which in multitudes of cases are the only important horizontal forces the structures are called upon to endure, the present state of knowledge is most unsatisfactory and discreditable. Publications professing to be scientific authorities give arbitrary, inconsistent, and occasionally unintelligible directions, while an examination of engineering practice as exhibited in large and costly structures in Australia and elsewhere reveals the most extraordinary inconsistencies. Structures in exposed positions and offering large surface to the wind are not infrequently absolutely devoid of wind bracing, while others placed in sheltered localities and offering but little surface are filled with costly lateral members having no possible utility except as aids against wind pressure.

Not many years ago a bridge over the Yarra, in Melbourne, occupying a very sheltered position, was condemned as liable to be overturned by the wind, and altered at great cost, although it would have taken 90lbs. to the square foot to move it according to the correct calculation, and 56lbs. to the square foot according to the engineer that reported upon it, while chimneys and railway vehicles that would overturn with not more than 30lbs. per square foot were continually to be found in positions infinitely more exposed. Furthermore, at the very time this lamentable waste of

money was going on in Victoria leading American engineers were constructing the gigantic Kinzua viaduct, more than 300ft. high, and giving it a resistance to wind pressure per square foot little more than half that possessed by the bridge so ruthlessly condemned.

More recently still a Royal Commission reported on certain iron bridges on a railway in Tasmania and condemned them as weak under wind pressure. The designer of the bridges protested, and further advice was sought. The matter being referred to the author of this paper, he calculated the resistance and found that it would take no less than 200lbs. per square foot to overturn the girders! And yet the Royal Commission condemned them, but never dreamt of condemning the railway carriages that passed over them, and which a similar calculation showed would infallibly capsize under a pressure of only 25lbs. Under these circumstances of conflicting authorities and wildly inconsistent practice it appeared to the writer that a paper on wind pressure, comparing and discussing the data and rules given in the books and detailing results of his own inquiries, calculations, and experiments, could not fail to be of use and interest.

For information upon wind pressure recourse is usually had to observatories equipped for meteorological work. These institutions usually possess some appliance professing to indicate the velocity of the wind, and more rarely an apparatus recording its pressure against a vertical surface. The instrument for determining the velocity is in all cases known to the author, either Robinson's or Hagemann's anemometer. At the Melbourne Observatory both are in use. In those cases in which the pressure itself is directly measured Osler's anemometer is employed. Robinson's anemometer consists of four hemispherical cups attached to arms radiating from a vertical axis, the rotational velocity of which is *supposed* to bear a constant relation to the speed of the wind. Hagemann's is simply a vertical tube, in which a partial vacuum is formed by the passage of the air over its open end, which partial vacuum is measured and recorded by suitable mechanism below. Osler's is a thin plate of metal, placed perpendicular to the direction of the wind, and provided with a spring behind, the compression of which shows at once on a suitable scale the pressure in pounds per square foot. It is if properly made by far the most satisfactory instrument of the three from an engineering point of view. The principal results obtained by the use of the above instruments at different observatories are as follows:—

BRITISH OBSERVATORIES.

Bidstone, near Liverpool, 90lbs. per square foot; Greenwich, 51lbs. per square foot; Glasgow, 48lbs. per square foot; Edinburgh, 27lbs. per square foot. All these results are by Osler's anemometer.

AUSTRALIAN OBSERVATORIES.

Sydney—153 miles per hour by Robinson's anemometer, corresponding to 117lbs. per square foot by Smeaton's and 22lbs. per square foot by Crosby's rule.

Williamstown, near Melbourne—35lbs. per square foot by Osler's anemometer. Wind from north.

Flagstaff Gardens, Melbourne—30lbs. per square foot by Osler's anemometer. Wind, south-west.

Domain, Melbourne—70 miles per hour by Robinson's anemometer, giving 24·5lbs. per square foot by Smeaton's and 10lbs. by Crosby's rule. More recently 60 miles per hour has been recorded by Hagemann's anemometer, giving 18lbs. or 9lbs. respectively according to the above rules. During this gale a chimney was blown over at North Melbourne, which, without counting the adhesion of the mortar, would require 20lbs. per square foot to overturn it in one mass.

Adelaide—25lbs. per square foot by Osler's anemometer, 70 miles per hour by Robinson's, corresponding to 24·5lbs. per square foot by Smeaton's or 10lbs. by Crosby's rule.

The preceding results show extraordinary differences, and are most perplexing to anyone engaged in the design of works, and were the higher ones adopted as data for designing would involve enormous increase in the expenditure upon many engineering and architectural structures—in fact, would absolutely forbid the existence of some of the most useful appliances of civilisation. Leading British and American engineers, however, have, by common consent, disregarded them and based their practice upon actual experience with engineering and architectural works. As an example of this kind of experience the case of railway carriages may be quoted. These are of approximately constant dimensions. They exist in enormous numbers in almost every part of the world. They are continually standing or running in the most exposed positions on high embankments, or viaducts, and their failure to resist wind pressure would lead to appalling accidents that could not fail to be reported far and wide. And what is the result? Why, simply this, that standard and Irish gauge vehicles which calculation shows would overturn in various cases with from 25lbs. to 35lbs. per square foot never do overturn, unless exposed to a tropical cyclone of such intensity that towns, houses, and ships are destroyed, and provinces depopulated by them, and that narrow-gauge vehicles, which would overturn with from 20lbs. to 30lbs. only, have been overturned so rarely, and under such very exceptional circumstances only, that the public make no objection to them on that ground.

Further, though not quite so definite, evidence is obtained from chimneys; these exist in countless numbers and in the quaint medieval styles of architecture now so popular are made comparatively tall and thin. There are thousands of such chimneys in

existence, many in very open and exposed situations, which, apart from the adhesion of the mortar, would infallibly overturn with a pressure of not more than 15lbs. per square foot. How much the adhesion of the mortar helps them it is hard to say, but it certainly cannot double their resistance. These chimneys are regarded by architects as perfectly safe, although placed in positions where their fall would almost certainly cause loss of life.

The most valuable contribution to the subject of wind pressure for many years has been made by Sir B. Baker, in connection with the Forth Bridge. He established three Osler anemometers, one being of the gigantic area of 300 sq. ft., the others small, and arrived at the most important and valuable result that the average pressure on an object as large as a railway carriage or small house was not more than about two-thirds of that indicated by the small instruments previously used. He also showed that the effect of inertia of moving parts, unless carefully guarded against, might enormously exaggerate the apparent pressure, and thus probably accounted for the incredibly high results sometimes given. He also made very valuable experiments on the effect of wind on plates and lattice work, which are to be found described in "Stoney on Stresses," p. 524, and, therefore, need not be repeated here.

In "Engineering" of May 30th, June 6th and 13th, 1890, is to be found a complete account of some most interesting researches by Mr. O. T. Crosby on wind pressure. The experiments were made by attaching the object to be experimented upon at the end of an arm projecting from a vertical axis which could be rotated at a known velocity. The result of the experiments which took place at linear velocities of from ten to 100 miles per hour was entirely to negative the earlier theoretical deductions and experimental determinations as to the law connecting velocity and pressure. These earlier formulæ were all of the form $P = cV^2$, and when P was expressed in pounds per square foot, and V in miles per hour, c was given as .005 by Smeaton and Rouse, and .0035 by Dines ("Engineering," 14th March, 1890, p. 333). Crosby, on the contrary, makes P vary directly as V , and the formula $P = \frac{V}{7}$ represents closely his results for a plane surface.

He himself expresses surprise at this result, but states that both he and his assistant verified it repeatedly with the whirling apparatus, and also with an Osler anemometer placed upon an electric locomotive travelling at various speeds up to fifty miles per hour.

The experiments carried out by the author were intended, first, to corroborate or negative Crosby's remarkable conclusion that the pressure varied directly as the velocity, and, next, to determine the relation existing between the pressure on solid bodies of rectangular, pyramidal, conical, or other form, and that on thin flat

surfaces which in size and shape corresponded to the projections of the solids in question.

For this purpose it was necessary first to obtain an artificial wind, a current of air of uniform or nearly uniform velocity and direction. For this purpose an accurately formed screw propeller with four blades of 28in. diameter and 40in. pitch was prepared and placed at one end of a tube 30in. diameter and 36in. long, and driven at a high speed by means of the Otto gas engine, at the engineering laboratory of the University. It was hoped that this would give a uniform blast, but such was not found to be the case. Instead thereof it produced a cylindrical shell about 6in. thick of helically moving air surrounding a central core of dead or motionless air. After a number of experiments it was found that by placing a longitudinal radial diaphragm in the tube, and by adding at the end a peculiar funnel-shaped attachment, the axis of which was a tangent to the helical path of one particular portion of the air, it was possible to obtain a jet of air of fairly uniform direction and velocity, having a cross section of 12in. by 10in., or an area of 120 sq. in. This jet of air was tested in various ways, the direction being studied by the aid of a small flag, while the velocity was given by means of a Revy's current meter, and checked by a counter attached to the axis of the propeller.

To determine the pressure on surfaces or solids of various forms the following arrangement was used:—A large and new engineer's surface plate was placed on a very firm support, cut off as far as possible from the vibration of the machinery, and accurately levelled. On this was placed a very carefully made three-wheeled carriage with gunmetal wheels turning on very fine steel centres. This carriage had been originally made for delicate physical experiments, and belonged to the physical laboratory of the University. The surface plate and carriage were cased in, so as to be protected from the wind, and from the carriage a thin stem rose up, passing through a slot in the casing and terminating in the centre of the air jet. On this stem were carried the surfaces and solids experimented with. The former of these were made of stout cardboard, while the latter were in most cases geometrical models belonging to the physical department of the University. The force of the wind was measured by a delicate spring balance, which, prior to use, was tested by means of a set of standard weights. The apparatus worked well and gave no trouble. Its indications were fairly precise, the wind fluctuating but very little owing to the gas engine being provided with a large flywheel, and there being also a second flywheel on a countershaft between the engine and the blowing apparatus.

The first experiments were made to determine the law connecting the velocity and pressure. A variety of tests were made with discs, spheres, cubes, and rectangular plates, the gas engine being made to run alternately as fast and as slow as possible by altering

the adjustment of the governor, the speed of the air being taken by the Revy meter. The results were not all strictly in accord. A number of them made with the meter running alternately 723 and 1,402* revolutions per minute conformed very closely to the formula $p = C v^{\frac{3}{2}}$, thus agreeing with neither Smeaton nor Crosby, but lying somewhere between. Another set with the meter running alternately 523 and 1,284 revolutions gave $p = c v^{\frac{7}{6}}$, thus approaching Crosby's determination.

These tests, based on an extreme range of velocity of less than $2\frac{1}{2}$ to 1 were felt to be insufficient to settle so important a matter. An Osler's anemometer was therefore constructed, having a plate 1ft. square, and fixed upon a bicycle that was led or driven at various speeds from 1 to 15 miles per hour. The pressures, however, proved too small to measure with certainty, and the area of the plate was then increased to 3.6 sq. ft., when fairly definite results were obtained, as shown:—

Speed in Miles per Hour.	Actual Pressure. Lbs. per sq. ft.	Ditto. by Smeaton.	Ditto by Crosby.
0	0	0	0
2	Not measurable	.02	.28
4 .....	.15	.08	.57
6 .....	.35	.18	.86
8 .....	.44	.32	1.14
10 .....	.83	.50	1.43
14	1.44	.98	2.00
15	1.67	1.12	2.14

The above results, though fairly consistent in themselves, and corresponding to the formula $P = \frac{V^2}{140}$ are so different to either

Smeaton's or Crosby's as to suggest the need of further tests on a much more extended range of velocities.

The next series of experiments was intended to determine the relation existing between the pressure on solids of various forms and on thin plates or cards corresponding in area to the projection of each solid. Thus a cube was compared with a card equal in size to one of its faces, a cylinder with a rectangular card of equal length and of width corresponding to the diameter of the cylinder, a square pyramid with a triangle whose base was one basal side of the pyramid and whose height equalled that of the axis of the pyramid, a sphere with a circle of equal diameter—the object being to obtain a modulus or number which when multiplied by the pressure on the plate would give that on the solid. To detail

* Each revolution of the meter corresponded to 1ft. of motion of the air; 1,402 revolutions was therefore about sixteen miles per hour.

all these experiments, which were very numerous, is unnecessary. General results were as follow:—

Cube.—The pressure on a cube was found to be as nearly as possible the same, whether the wind was parallel to a side or a diagonal, and was .9 of the pressure on a square card equal in size to one face of the cube. Modulus = .9.

Rectangular blocks of varying proportions: x = length in direction of wind; y and z the other dimensions.

$x = 2y = 2z$	modulus .8
$x = 3y = 3z$	“ .7
$y = 2x = 2z$	“ .9
$y = 3x = 3z$	“ .9

A block, representing a tower square in plan, and having a height equal to three times its width of base, gave a modulus of .9 when the wind was perpendicular to one face. When the wind was in the direction of a diagonal the effect was, as nearly as could be measured, the same.

Pyramid.—A pyramid of square base, having a height of about three times its base, and representing fairly well a not uncommon form of church spire, gave a modulus of .8 when a side was presented to the wind. When one angle was presented to the wind the total pressure was increased by about one-fourth.

Cylinder.—Two cylinders of different sizes were tested and found to give a modulus as compared with planes of the same height and width of .52, or slightly more than one half. The usual rule is in this case fairly accurate.

Octagonal Prism.—One of these was tested corresponding in size to one of the cylinders, and was found to experience a pressure about 10 per cent. greater than its circumscribing cylinder did. This was doubtless due to the disturbance of the current of air by its angles. This result will be of value in connection with towers and chimneys, such as those used by the Melbourne tramways.

Cone.—A cone having its height about three times its base gave a modulus of .50.

Sphere.—Modulus = .36.

Hemispherical Cup.—As used in Robinson's anemometer:—Convexity to wind, .36; concavity to wind, 1.15.

Roofs.—The results given in Stoney, p. 524, as to pressure on roofs of various pitches were verified for pitches steeper than 45° . At low angles the results were rather higher than the table, but the experiments were not altogether satisfactory. The roofs were further tested in connection with vertical walls of a height rather greater than that of the roof. These walls tend to deflect the wind upward and relieve the roof of pressure to a very marked degree. With a roof of 60° pitch the pressure was thus reduced 40 per cent., and with a roof of 45° pitch 80 per cent., while at

30° there was no perceptible pressure on the roof. When the wall is extended in the form of a parapet this sheltering effect is largely enhanced, so much so that with a parapet one-sixth of the total height of the roof 70 per cent. of the pressure was removed from a roof of 60° pitch, and one of 30° pitch actually experienced a negative pressure to a slight degree. Experiments were also made on the lifting effect upon a roof of a building, having the two sides and one end closed, but the other open to the wind, and it was found that the upward pressure was equal to the pressure of the wind upon a normal plane.

Girder Bridges.—The case of a bridge, consisting of two plate girders connected by a deck placed either at the top or bottom of the girders, was studied, and it was found that if the distance between the girders was equal to their depth the leeward girder was fully sheltered, but that if that distance was double the depth one-fifth of the area of the leeward girder should be added to that of the windward girder, as being exposed to the wind pressure.

Lattice Work.—A card 6in. by 8in., or 48 sq. in., was tested in comparison with a similar card in which sixteen rectangular openings had been cut, thus changing it into a grating, the area of which was 27·4 sq. in., or 57 per cent. of the solid card. The pressure on the grating was, however, found to be 83 per cent. of that on the solid card. Placing the grating in front of the card it was found that the pressure on the latter was reduced as follows :—

Card 6in. x 8in.	pressure	·37lbs.
Card grating 1½in. in front	"	·23 "
" 3in. "	"	·17 "
" 4½in. "	"	·12 "
" 6in. "	"	·11 "
" 7½in. "	"	·16 "
" 9in. "	"	·20 "

During the course of the experiments my assistant, Mr. Jas. Mann, called my attention to two very curious phenomena. The first of these was the shelter a small surface receives from a larger one placed behind it. This was tested in numerous cases, one of the most striking of which was when a card 3in. square was exposed to the wind and a 9in. diameter disc placed *behind* it. Without the disc the small square received ·15lbs. pressure, with the disc 12in. behind this was reduced to ·14, at 9in. ·11, at 6in. ·09, at 3in. ·07, and at 1in. distance the square card received a pressure of only ·03lb., or one-fifth of what it endured if the disc were removed. The second was the apparent attraction of a large surface for a small one *behind* it. This was found to be due to a current setting *towards* the back of the surface exposed to the wind. Two experiments illustrating this peculiar effect may be mentioned. In the first the 9in. disc was fixed in the current of air and a second disc

of slightly over 7in. diameter supported on the carriage behind it. When the two discs were 4in. apart the rear one was dragged forward or towards the wind with a force of one-fifth of that with which it was driven back when the larger was removed. At less or greater distances than 4in. the effect was reduced. In the second a 3in. disc was experimented upon, a second disc of equal size being placed in front of it. When the two discs were 2in. apart the rear one was unaffected. When the distance was less than 2in. it was driven forward; when greater, backward.

Another curious effect was noticed when a plane surface parallel to the wind was brought in contact with a cylinder or sphere so as to stop the escape of the air on one side. In this case the pressure on the cylinder or cone was immediately augmented by about 20 per cent. Thus it appears that the security of a circular chimney may be impaired by the erection of a building beside it. This effect was not noticed with cubes and rectangular blocks.

The above experiments were on a small scale, and will not carry as much weight as if they had been on a larger one. Possibly they may at some future time be repeated with more powerful and perfect apparatus. But should they be, it is not, in the author's opinion, likely that any important alteration in the results will take place. Small experiments, if carefully made and honestly reported, do not often give results differing seriously from those obtained on a larger scale.

The following conclusions, deduced from a consideration of all available dates, are submitted as reliable guides in practice in the southern and south-eastern parts of Australia.

1. Plane surfaces of not less than 300 sq. ft. area are subject to a maximum wind pressure of not more than 20lbs. per square foot, and smaller surfaces to a pressure of not more than 30lbs. per square foot in exposed positions. In very sheltered positions half the above values may be taken, and intermediate cases may be dealt with according to judgment.

2. Square, round and octagonal towers, chimneys, spires, railway carriages, girder bridges and roofs are to be reduced to their equivalent normal plane surfaces by means of the moduli and rules given in the earlier part of this paper.

3. Factors of safety of not less than 2 for stability and 3 for strength should be used.

In concluding, the author desires to render his thanks to Messrs. Russell and Ellery and Sir Charles Todd, the directors of the Observatories at Sydney, Melbourne, and Adelaide respectively, for information as to wind velocities and pressures; to the physical department of the Melbourne University for loan of models and apparatus; and to Mr. James Mann, the assistant in the engineering laboratory, who arranged the apparatus and offered many useful suggestions during the course of the experiments.

2.—COMMENTS BY THE SOUTH AUSTRALIAN INSTITUTE OF SURVEYORS, INCORPORATED. UPON MR. SULMAN'S PAPER* ON "THE LAYING OUT OF TOWNS."

Read by JOHN H. PACKARD, Hon. Secretary South Australian Institute of Surveyors, Incorporated.

Whilst complimenting Mr. Sulman on the interesting and able manner in which his paper on "The Laying Out of Towns" is written, and expressing a desire that the subject so well initiated by him should be discussed with widely beneficial results, it being well known that in all the colonies many sites of towns have been ill chosen, we wish to take exception to some of his statements, which are fairly open to criticism, and which must strike many practical men as somewhat inconsistent and utopian.

LOCATION.

With regard to location he states "that in the first place a town should only be laid out where the conditions for its growth are present, such as a considerable area of surrounding agricultural land, subterranean mineral wealth, an important railway junction, or a port of shipment." It will readily be admitted that the above conditions are desirable and would be apt enough if sites were always obtainable with these advantages, but it must be remembered that in the majority of cases in a new settlement most of them are absent, railway lines are yet unmade, and mineral wealth undiscovered.

A shipping place, for instance, in the neighborhood of some agricultural or pastoral district may not possess all the essentials of a good site for a town, but is the best place on the coast for a small port; consequently a few blocks are laid out in the simplest form, which would possibly answer all requirements for very many years, but what would be thought of that man who should lay out a town in Mr. Sulman's approved "spider-web plan"? Not knowing its future possibilities, of course it must be laid out to suit the population of, say, Adelaide or Melbourne. The post office, telegraph station, and other public buildings must be in or near the centre, and consequently nearly a mile from the shipping place, causing great inconvenience to those using them, and a standing monument for, perhaps, scores of years to the folly of the designers.

In a new country it is impossible to foretell which places will be important, and, therefore, to carry out Mr. Sulman's views all towns should be laid out the same size. The existence of large towns is frequently the result of accidental circumstances, such as the discovery of a mine, as witness Ballarat and Broken Hill. In

* Read at the meeting of the Australasian Association for the Advancement of Science, held in Melbourne, January, 1890.

most cases the surveyor has simply to make the best of the site allotted to him, and, whether a supply of water is obtainable within a reasonable distance or not, here the town must go. The water must be brought to the town and the sewage find its way out. But even supposing that the surveyor laid out his town in a place fulfilling all the required conditions and with the proverbial attractiveness of the spider's web added, still up will go the real bricks and mortar town in close proximity to the centre of the work, whilst the survey pegs of the theoretic metropolis are rotting in the trenches or being ploughed up by the farmer.

It is only in surveying a country prior to settlement that Mr. Sulman's suggestions could be carried out, and, unfortunately for the adventurous profession we have the honor to represent, such an opportunity is of rare occurrence. The initial survey of South Australia, half a century ago, afforded such scope. Had Colonel Light, to whom credit is universally accorded for his selection of the site and for the design of Adelaide, had the privilege of perusing the paper now under consideration it is probable that the chief city of this province would now stand an imperishable monument to the spider's web system, instead of only showing, as it does, that the gallant colonel was conversant with a move or two on the chessboard pattern; and here we take the liberty of expressing our doubts as to the suitability of the new system, if adopted in its entirety, to replace the old, and are not yet prepared to abandon the simple geometry of the chessboard in favor of the mathematical complexities of the spider's web.

DESIGN.

Admittedly, in some respects, a city more beautiful from an architectural point of view could be built on Mr. Sulman's plan than in any other, but even then the extra beauty would be largely confined to the very centre of the town, and it is questionable whether some important considerations would not in this case, as in many others, be sacrificed at the shrine of beauty.

By reserving a sufficiently large space in the centre it is true that ample frontage could be provided for the erection of all the principal public buildings, and this part of the town could be made very attractive, but once leave the magic circle and the eligibility of position decreases in inverted geometrical progression as the distance increases. Every owner of city lands, not being the fortunate proprietor of one of those acute angles in which Mr. Sulman revels, has the disadvantage of having to travel round one or another of these angles before he can reach the architectural paradise of the centre. In short, the heart of the system is apt to be exalted at the cost of every other part of it.

Granted that the irregular frontages can be used up with good effect by an able architect, yet this would be at great sacrifice of frontage, which the owners would be reluctant to allow where the

land was very valuable; witness the sharp corners in London or Sydney, where nearly every foot is built upon, notwithstanding the great disadvantage of acute-angled and ill-shaped rooms; and the cost of filling up these awkward corners is out of all proportion to the accommodation afforded.

CHESSBOARD PLAN.

We are inclined to think that for practical purposes the chessboard plan, with proper provisions for squares and parks, is the best for a town, provided, of course, the natural features are favorable. The streets should, if possible, run about north-east and north-west, as this arrangement would ensure every street getting a fair proportion of sunshine during some portion of the day. In addition to the sanitary advantage, and in some respects the business convenience of this arrangement, it is found in practice that streets which have a fair share of sunshine in winter last longer than those altogether in the shade.

Rapidity of survey is the only advantage Mr. Sulman concedes to the chessboard system, but there are others of far greater importance, *e.g.*, the straight streets afford better facilities for the construction of railway, tram, and telegraph lines. The land by being divided into rectangular blocks can be used to the greatest possible advantage for buildings, court yards, and streets, whilst there need be no lack of scope for architectural variety.

STREET ALIGNMENTS.

The simplicity of marking the correct alignments of the streets is another point in its favor, and this is by no means unimportant. Even in the rectangular city of Adelaide the question of street alignments has been found a very troublesome one, partly on account of too liberal measurements being given in the original survey for the reputed area, and it is at the present moment the subject of legislation after years of persistent agitation on the part of this Institute.* The difficulties in the way of a settlement would have been far greater with the short lines or curves and the irregular angles of the spider's web system.

CURVES.

The idea of laying out the streets of a town in curves is by no means a new one in South Australia. As long ago as 1871 the late Mr. Arthur Cooper, then Deputy Surveyor-General, designed the town of Port Pirie with the longitudinal streets following the trend of the arm of the sea forming the harbor, and which happened to be a nearly regular curve; the transverse streets were laid out in straight radial lines. Port Pirie is a rapidly improving town, and will eventually furnish a very good example of the

* Legislative enactment has since been obtained.

pleasing effect of handsome buildings erected round a graceful curve. Whenever the natural features are favorable, as following the bend of a sea frontage (as in this instance), of a river, or winding round a hill to obtain an easy gradient, we think that curves should be made, as the advantages gained exist for all time, and more than counterbalance the disadvantages of irregularity of block and the increase of survey work involved in their use; but we are scarcely prepared to advocate their use where straight lines will answer all purposes. Speaking as surveyors, we should like every township in the province to be laid out in curves, as this would make a great increase of survey work of an interesting character, but we can scarcely expect to arrange these matters to suit surveyors only, and public opinion is apt to place utility before beauty.

Whilst recommending the chessboard plan generally as a basis, we should, of course, deviate from it whenever the natural features indicate the desirableness of doing so. Every different site should have its own design, and to the experienced surveyor the proper place to run the streets will be apparent on a careful inspection.

WIDTH OF STREETS.

Three-chain streets should, we think, rarely be admitted, as they separate the sides too widely and make them almost like portions of distinct towns. We have some instances in South Australia where this has been the effect, and we are inclined to think that two chains is about the maximum that should be allowed, while, at the same time, the width should rarely be reduced to less than a chain and a half and never less than one chain, as it is impossible to foresee which streets are destined to become leading thoroughfares.

SUBSOIL.

It also appears to us that Mr. Sulman attaches undue importance to the necessity of a pervious subsoil for the site of a large town. We would not think of rejecting an otherwise favorable site for this reason only, as in these days the question of deep drainage is only one of time. For example, the subsoil of Adelaide is a stiff clay 30ft. to 60ft. thick, and yet during all the years that Adelaide existed without deep drainage it was always considered a most healthy city. When the site is unsuitable, through being badly situated for drainage, the more pervious the subsoil the better, but where a town is naturally well situated for drainage the character of the subsoil is, we think, of but secondary importance.

Who should design towns?

ARCHITECTS DESIGNING TOWNS.

We are not insensible to the advantage of consultation amongst the members of the three professions of architect, engineer, and surveyor, so as to produce the best design for a proposed town.

It has been truly said that "two heads are better than one," and we shall hail the day when landowners desire the united services of the three professions in designing and laying out their towns, but until this auspicious time arrives we feel bound to respect the ancient admonition, "*Ne sutor ultra crepidam*," and not claim to ourselves the right of designing all the houses as well as marking out the lots on which they are to be built, while at the same time we can scarcely be expected to concede that the designing of towns belongs solely to the architectural profession, leaving to the surveyor merely the privilege of driving in the pegs.

Though Mr. Sulman may smile at our ignorance of the history of the professions, we are bound to confess our inability to follow him when he refers to the "honored positions we, the architects, once occupied, but from which we have been too long excluded." We wonder what happened to disturb this excellent arrangement, and from what they have been excluded?

Mr. Sulman's remarks on this part of the subject lead us to notice a tendency which we have often observed: to blame surveyors for all the blunders in sites as well as the badly laid out towns that unfortunately exist, but a very little consideration will show the injustice of this tendency. As a matter of fact, as we have already pointed out, in private work the surveyor seldom or never has any voice in choosing a site. In the days when all the agricultural land around Adelaide was selling at so many pounds per foot, if the surveyor had ventured to suggest pegging out a spider's web on a square plot of land or the digging of holes to prove the subsoil he would have been accounted a lunatic, and, unless he had decided to retire from this kind of business, his business would have quickly retired from him. We recollect one surveyor who was employed to survey a township in the hills near Adelaide, and who took such interest in his work as to lay out his streets in faultless curves sweeping in easy gradients round the contour of the hills. He has long since abandoned the scene of his triumph, and seeks in distant lands that appreciation of his merits which they failed to arouse in South Australia.

LEGISLATION.

In noting Mr. Sulman's remarks under this head we do not see that No. 3, limiting the area to be included in a title, would have any practical effect in preventing overcrowding, as fifty buildings could be huddled together on one acre as well as on separate blocks of one-fiftieth of an acre, and it would work hardship in some instances; for example, we know of one case in Adelaide where it was necessary to issue a title for a strip of land only 6in. wide. In most cases probably a strip like this might be tacked on to the adjoining land, but it might not always be convenient; for instance, the adjoining land might be mortgaged, and it would then be undesirable to join the two pieces of land in one title.

In the legislation, which we have already referred to, in this province it is provided that permanent marks should be laid down in all towns, from which the true alignments of the streets and also the boundaries of the sub-divisions can be definitely fixed. The want of this provision has been very much felt here. Every surveyor has had hitherto to use his own judgment as to starting points, and there is often room for considerable difference of opinion. In all future surveys of townships it is desirable that permanent marks should be laid down; fixity of position being so intimately connected with indefeasibility of title that both are indispensable to the proper working of the Real Property Act.

RECOMMENDATION TO GOVERNMENT.

Mr. Sulman's suggestion that the Government of each colony should receive a recommendation from the Australasian Association for the Advancement of Science on the laying out of towns is certainly a good one, as such a course may be the means of preventing some of the undoubted errors of the past from being repeated in the future. We might mention here that the law in force in this province provides that no township plan shall be received into the Lands Titles Office until it has been approved by an officer appointed by the Government for that purpose.

In conclusion, we would remark that, though differing somewhat from Mr. Sulman's views, we feel that he is deserving of the thanks of ourselves and the public for expressing his thoughts on this important subject in such a clear and intelligent manner, and trust he may be rewarded by seeing the seed that he has sown bear fruit in the selection of more healthy and suitable sites, and the adoption of better designs by the present and future generations.



3.—THE PRACTICE OF ROAD-MAKING IN SOUTH AUSTRALIA.

By C. T. HARGRAVES, M.I.C.E.

(WITHDRAWN.)



4.—A STANDARD PRESSURE GAUGE.

By C. W. SMITH, A.M.I.C.E.

5.—THE END-LOADING OF RAILWAY SHEEP TRUCKS.

By J. C. B. MONCRIEFF, M. Inst. C.E.

PLATES XVI.A, XVI.B, XVI.C.

The growth of sheep has always been one of the staple industries of South Australia, and all questions dealing with the economical conduct of the business have therefore a special interest in this country. Among these the cheap and rapid carriage of the animals is particularly important, and has received a very large amount of attention during many years past. In fact, ever since the railway system of the colony began to extend into the interior of the continent the carriage of sheep has grown in importance with the increasing length of the railways. The size of the trade has demanded the expenditure of large sums upon appliances to cope with it, and the problem which it presents to the railway engineer is how best to meet the convenience of the public, and at the same time to secure a fair return upon the outlay.

Different countries have this problem presented to them under varying aspects. Thus in England the numbers of sheep to be dealt with are comparatively small and the journeys short; at the same time the animals are valuable, and a considerable amount of care can therefore be given to each individual. In America the sheep are travelled long distances in large numbers to important inland centres, where they are killed, cooked, or frozen, and the carcasses are then carried long distances by railway in refrigerator cars. In South Australia the sheep are also travelled in large flocks over long distances to the inland railway stations, there loaded alive and carried long journeys—sometimes amounting to 700 miles. The value of each sheep is small, and this, combined with their number, precludes the possibility of much expense being incurred in handling them.

The method of trucking and untrucking must therefore be rapid and simple, more especially because in most of the long journeys they have to be transhipped once, or it may be twice, owing to the breaks of gauge which occur at Terowie and Wolseley.

These considerations have led to the adoption of a method known as the end-loading system, which has been eminently successful, and which, so far as the writer knows, is peculiar to the colony of South Australia. It is, therefore, thought worthy of a short description, more especially as the principle seems applicable to all the Australian Colonies and possibly to other parts of the world where the conditions are similar.

In order that the special features of the end-loading system may be readily understood it is necessary to explain the arrangements which it superseded in the colony, and which are still used in other places.

Sheep trucks are constructed with two floors, one above the other. These were loaded and unloaded through doors in the sides over wharves specially constructed with ramps and small yards, each of which latter was capable of holding the exact number of sheep required for one floor of one truck. The number of ramps and yards varied according to the importance of the station, and a special siding was required for this trade. Seven ramps, providing accommodation at one time for a similar number of trucks, was considered a large equipment for one station, and with these four (4) hours were occupied in loading twenty-eight trucks, while an engine was required for shunting each batch as it was dealt with. Half this time was needed for unloading a train of the same size. The drafting of the sheep into the yards, driving them into the trucks, closing the doors of the latter and the gates of the former, also the moving of the loaded trucks and placing the unloaded ones in the exact position opposite the ramps, all required labor, care, and time. In fact, the whole process was cumbersome and expensive. Fitting up a sheep wharf was an expensive item in the construction of a station, varying according to the number of ramps provided. Fifteen years ago there were only three stations thus provided, and the cost incurred at each was £1,300. There was then only one gauge in the colony upon which sheep were carried at that time, and therefore the question of transhipping had not risen. It is difficult to see how this operation could have been carried out speedily or economically with the appliances described above.

Under the present system the trucks are fitted with end doors, which, when opened, form the whole train—no matter what its length may be—into an upper and lower sheep lane. An inclined ramp with two floors suited to the heights of the truck floors is provided, a small crush yard leads to each floor of the ramp, and a large yard for the folding of the sheep completes the necessary appliances, but drafting yards are now generally added for the convenience of sheepowners; they are not, however, essential to the principle.

A set of model yards, with the loading ramp, is shown on Plate XVI.A. Yards of this description are provided at all stations where there is a constant trade, and the cost of erection is about £400. The enlarged views upon Plate XVI.B show in detail the method of constructing the standard loading and unloading ramp at stations where yards are provided.

For loading small lots of sheep at unusual places and for unloading them at stations where yards are not provided a travelling stage or ramp, similar to that shown upon Plate XVI.c, is provided on each gauge. Those ramps are folded up after use and run from station to station with the train. In loading with these portable ramps the yards are formed temporarily with a few movable hurdles, which are carried about with the ramps. For unloading,

the ramp is simply unfolded, the truck doors opened, and the sheep run on to the ground.

For transshipping at a break of gauge station a strong fixed ramp of simple construction is provided, as shown on Plate XVI.A, one end being the proper shape to fit the broad-gauge trucks and the other end suitable for those on the narrow gauge. The empty train on the one gauge is placed against the ramp on its own side, and when the loaded train arrives on the other gauge it is at once run against the other side of the ramp. The truck doors are then opened and the sheep run through at a great speed, urged by a dog which is generally kept for the purpose and specially trained to the duty. The doors of the newly loaded train are then closed and the journey continued on the other gauge.

The time occupied in loading thirty-five trucks under this system does not exceed one (1) hour. The unloading of the same sized train can be done in twenty (20) minutes.

The time required for transshipping a train of similar length, and which would contain 4,000 sheep, is forty-five (45) minutes.

The advantages of the end-loading system are as follow:—

(1) The cost of the appliances has been greatly reduced, thus rendering it possible to place them at a much larger number of stations than would have otherwise been the case; also to erect increased conveniences for sheepowners in the shape of drafting yards, &c.

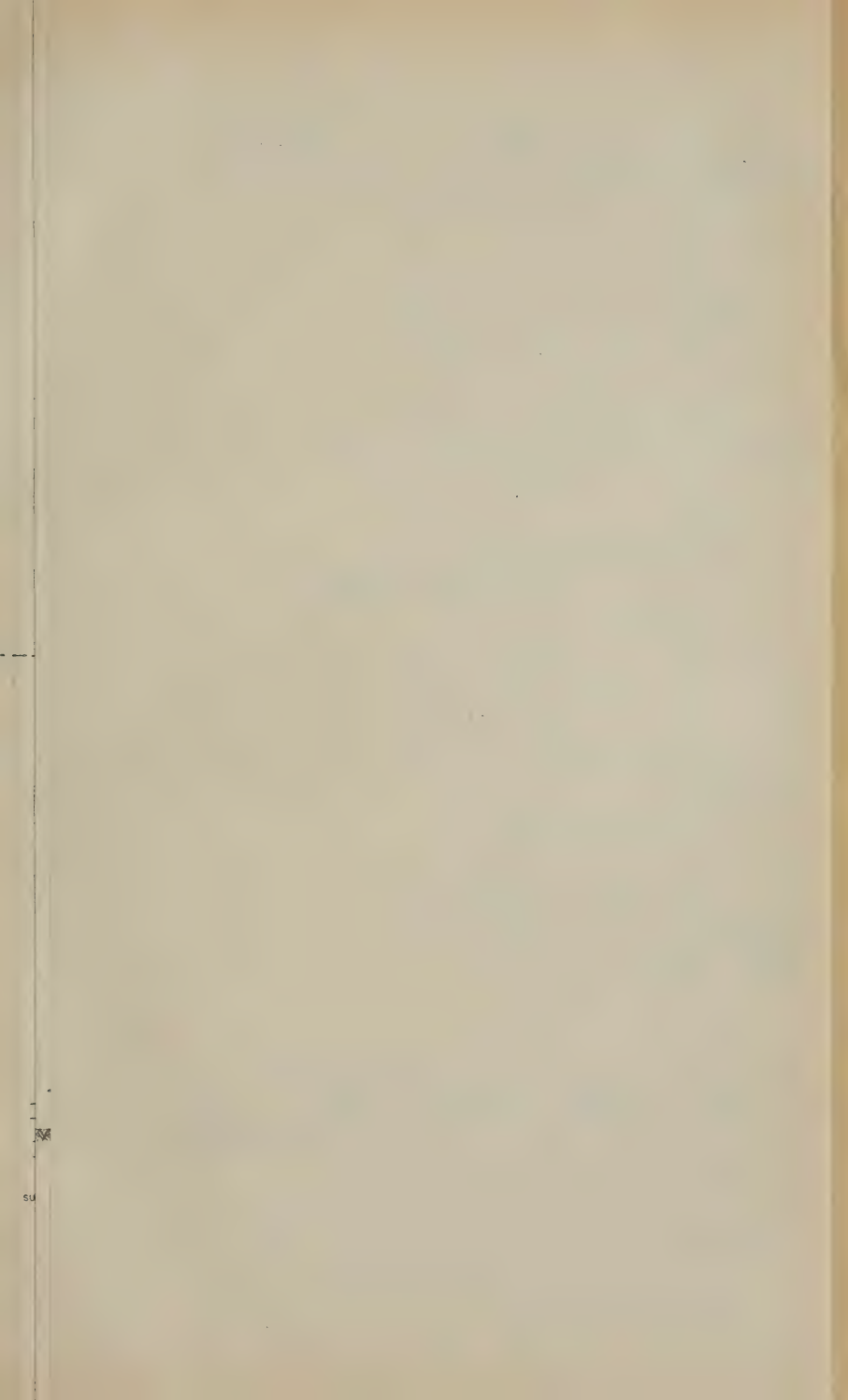
(2) The speed of handling has been greatly increased, which is of great importance upon long journeys.

(3) The sheep are handled in large numbers and in a natural manner, which lessens the damage to them.

(4) The transshipping at break of gauge stations has been rendered possible at great speed and small cost.

(5) Through the use of the travelling ramps owners can load and unload at any station, while formerly they could deal with sheep only at stations which were fitted up for the purpose and which, owing to the cost of the appliances, could only be placed at long distances apart.

(6) The cost of handling has been reduced, thus admitting of reduction in freight charges, the importance of which will be seen when it is stated that during the year ending June 30th, 1892, more than 800,000 sheep were carried upon the South Australian railways.

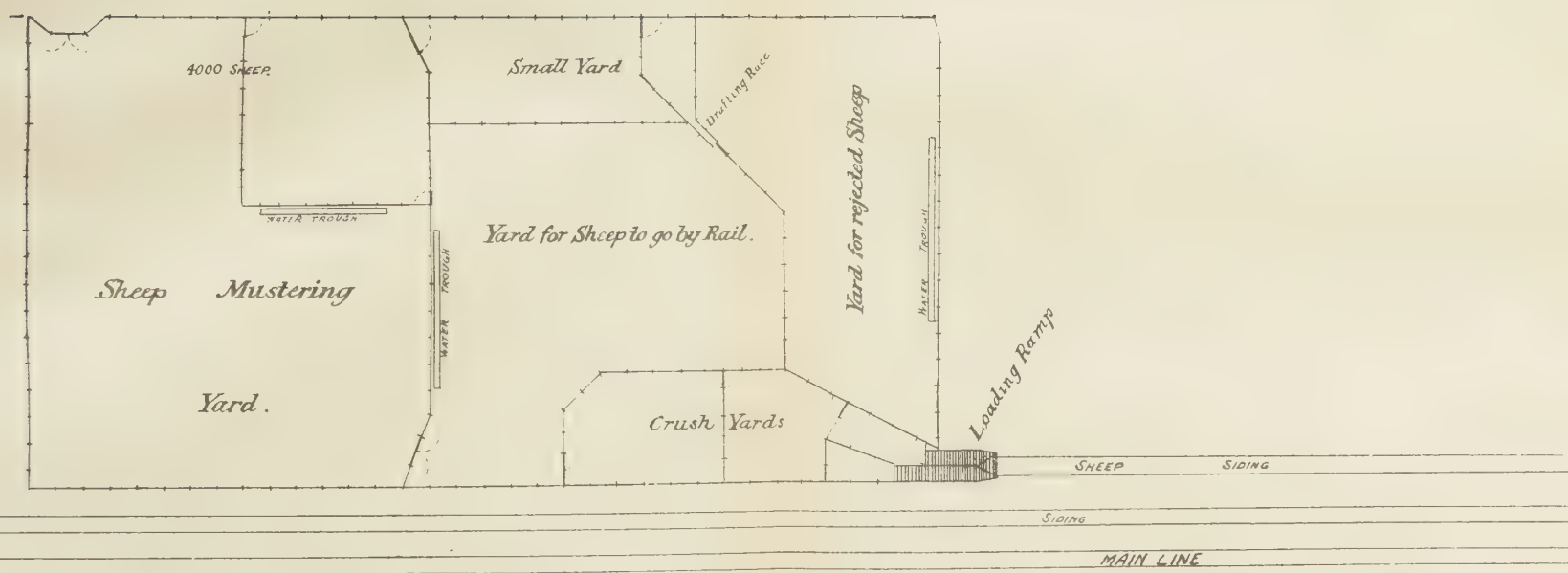


END LOADING OF SHEEP TRUCKS

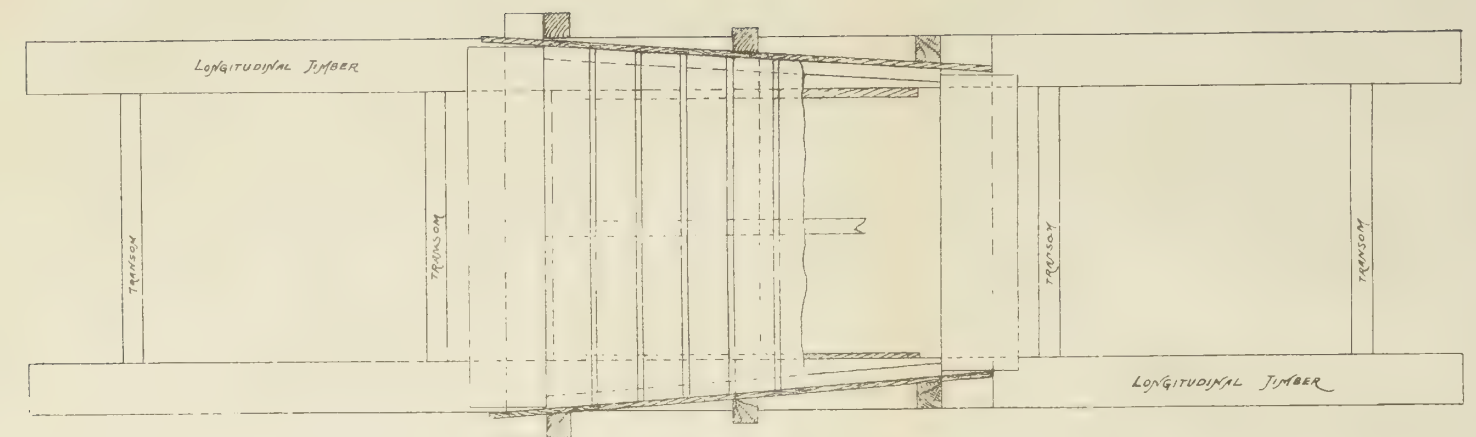
Standard Arrangements

SOUTH AUSTRALIAN RAILWAYS

Plate No. 1



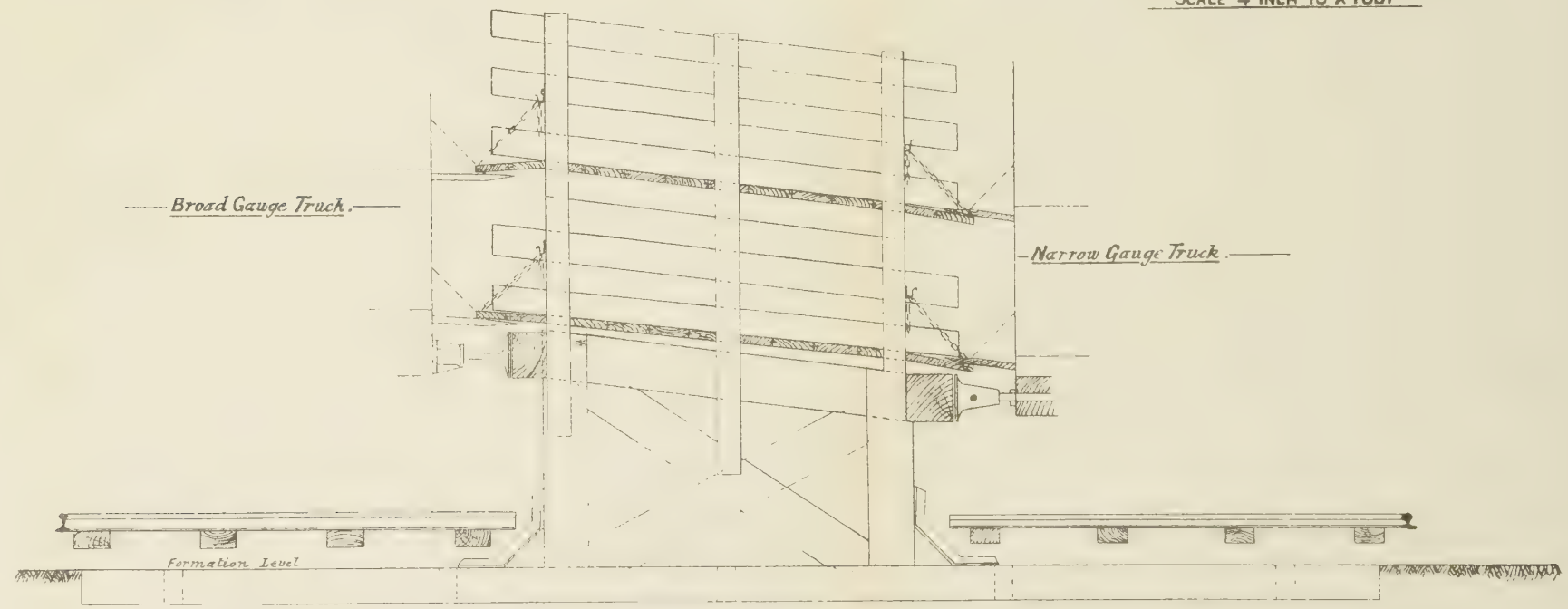
SCALE
60 FEET TO AN INCH



Plan

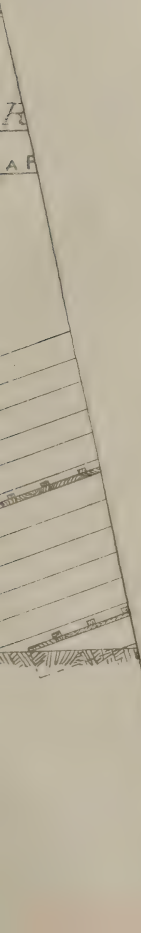
TRANS SHIPPING STAGE

SCALE 1/4 INCH TO A FOOT



Elevation

Plate XVI.a



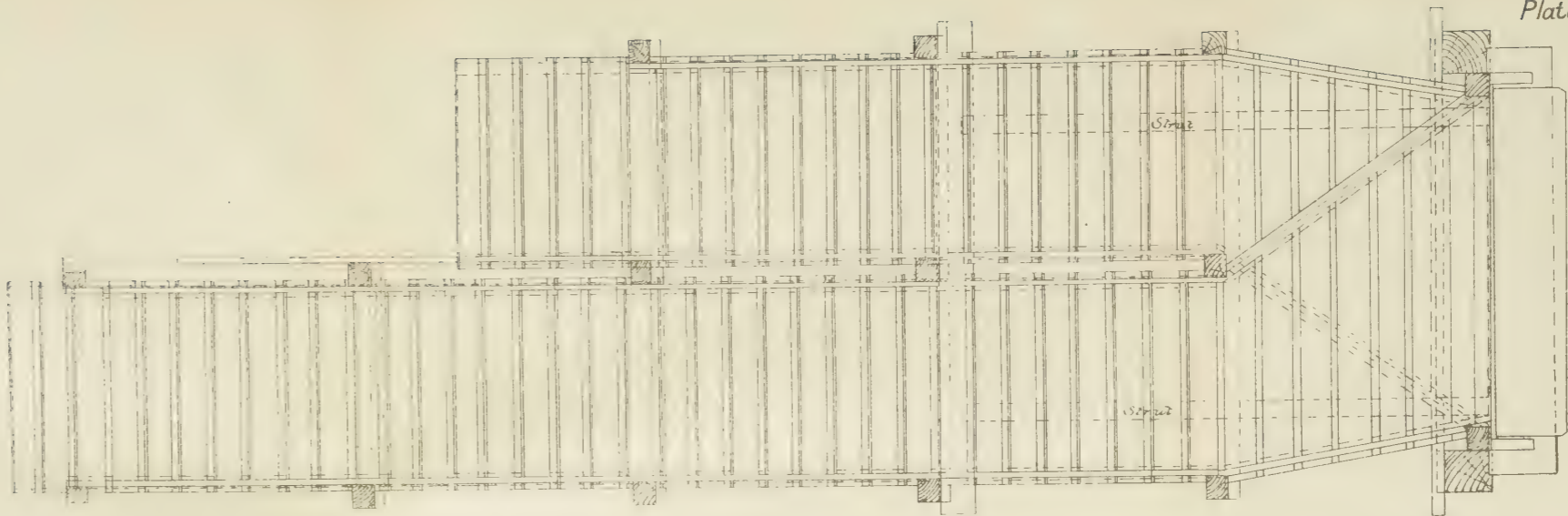
END LOADING OF SHEEP TRUCKS

Standard Arrangements

SOUTH AUSTRALIAN RAILWAYS

Plate No. 2

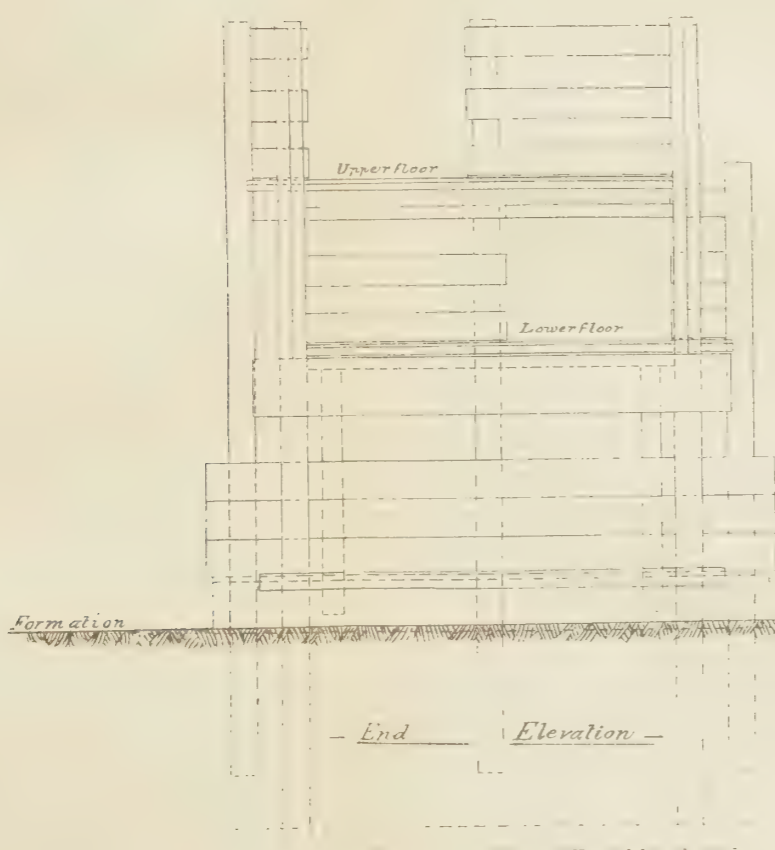
Plate XVI b.



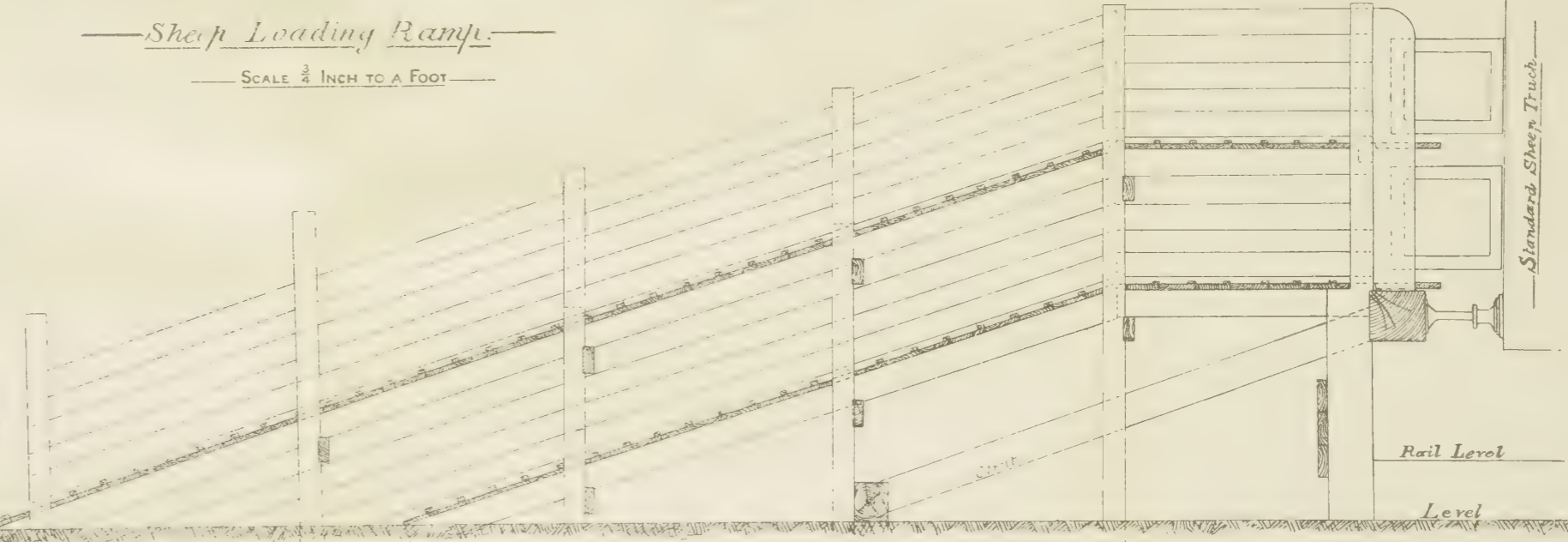
Plan

Sheep Loading Range

Scale 3/4 inch to a foot



End Elevation



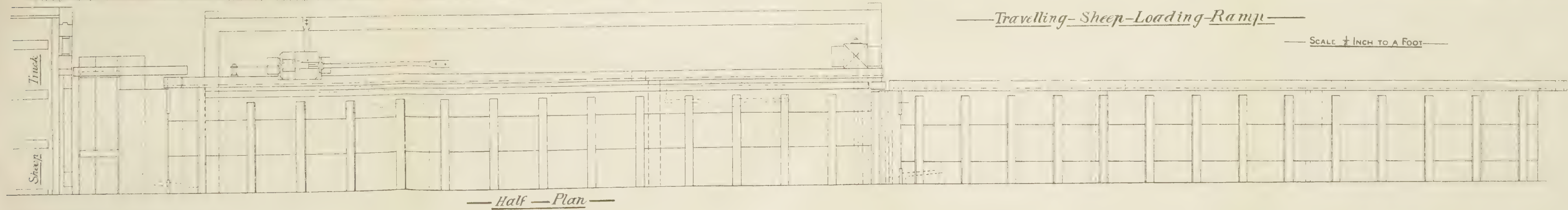
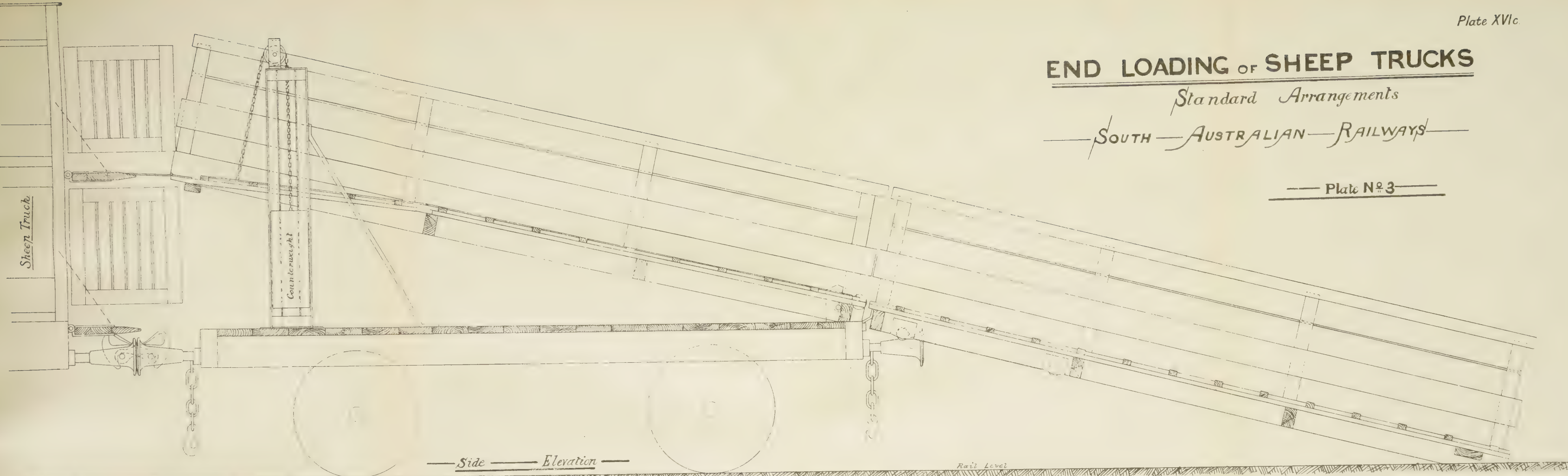
Side Elevation

END LOADING OF SHEEP TRUCKS

Standard Arrangements

SOUTH AUSTRALIAN RAILWAYS

Plate No 3



Travelling Sheep-Loading-Ramp

SCALE $\frac{1}{2}$ INCH TO A FOOT

6.—TRANSITION CURVES FOR RAILWAYS AND TRAMWAYS.

By S. SMEATON, B.A., C.E.

PLATE XVII.

Theoretically the superelevation of the outer rail on the circular curves of railways and tramways ought not to be continued beyond the tangent points, but should end abruptly; in other words, the rails throughout the straight portions of the line should be level transversely. As this would necessitate an abrupt rise of some inches in the rails, obviously in practice it is impossible, and it has been customary for engineers on construction to extend the superelevation along the straight to a point at some distance from the tangent, reducing it from its full amount at the tangent to *nil* at the point mentioned. This “run out,” as it is termed, is on a fixed grade, determined beforehand as most suitable throughout the line, so that its length is directly proportional to the amount of superelevation on each curve. Maintenance engineers subsequently modify this arrangement by having the tangent point, with the adjoining portions of the straight and of the curve, pulled over towards the centre. This operation is of twofold advantage: first, the passage of rolling-stock from the straight portion of the line to the curved, and *vice versa*, is not so sudden, the angular change of direction being more gradual; and, second, the “run out” of the superelevation (which, under the first arrangement, was on the straight, and therefore somewhat detrimental to safety) is now on an arc, the curvature of which at any point is *approximately* proportional to the superelevation. The gradual and easy passage of the rolling-stock from the straight to the curved portion, and *vice versa*, contributes largely to the comfort of travellers, and alone justifies this alteration. The chief objections to this alteration of the position of the line are:—First, a curve of less radius than that of the original has to be introduced, in order to leave the greater portion of the circular arc intact; and, second, the operation has to be performed by eye, and is necessarily somewhat inaccurate. A *parabola* has long been recognised by engineers as the curve pre-eminently suitable for railway and tramway curves; but the difficulty attending the laying out of such in the field—not only on survey, but subsequently during many repetitions on construction—has been an insurmountable hindrance to its universal adoption. To overcome this difficulty Froude suggested that an elastic curve, of *short length only*, should be introduced at the junction of the straight and curved portions; and he proposed that the original circular arc, except a short length at the end, should be set out in the usual way, and then transferred nearer the centre by an amount calculated to suit various cases, the position of the straight portions of the line remaining unaltered. It is obvious that by this transfer of the arc the radius is somewhat reduced. Such a reduction is

not always desirable. Rankine, in his work on civil engineering, describes the laying out of such, and of late American engineers have adopted it under the name of the "cubic parabola," but without the reduction of the radius of the circular arc mentioned above. This seems not only to meet all requirements, but the formulæ in connection with it can be made so simple that very little extra time is required for the setting out of such in the field.

Briefly, then, what is requisite for a transition curve is that the radius shall be *infinite* at a point on the straight to be determined upon, and shall diminish proportionately with the distance from that point till, at a junction effected tangentially with the original curve, the radius has been reduced to that of the circular arc. On such a parabolic curve, then, the super-elevation is everywhere proportional to the curvature. The cubic parabola transition curve has been used with success on railway and tramway lines in America. In New South Wales it was adopted on some deviations made in the Blue Mountains, and South Australia has one or two on existing lines, while on new lines in the future all curves of less radius than twenty chains will be set out with transition curves.

It will be unnecessary to follow up the reasoning by which the formulæ for setting out such were evolved. Below will be found equations of the simplest form and suitable for use in the field

First compute, in the ordinary way, the superelevation required for the circular arc

$$\text{Superelevation in ft.} = g \frac{V^2}{15 R} \dots\dots\dots (1)$$

g = gauge in feet

V = velocity in miles per hour

R = radius of curve in feet.

Now determine the most suitable grade for the superelevation to be run out on (1 in 360 is adopted in South Australia)

Therefore

Length of transition curve in feet = superelevation \times 360 or
A C (Fig. 1).....(2)

The original circular arc is not set out, but the positions of new tangent points and lines are determined thus :—

$$\text{Shift or H G (Fig. 1)} = \frac{(\text{length in transition curve in feet})^2}{24 (\text{radius in feet})} \dots\dots\dots (3)$$

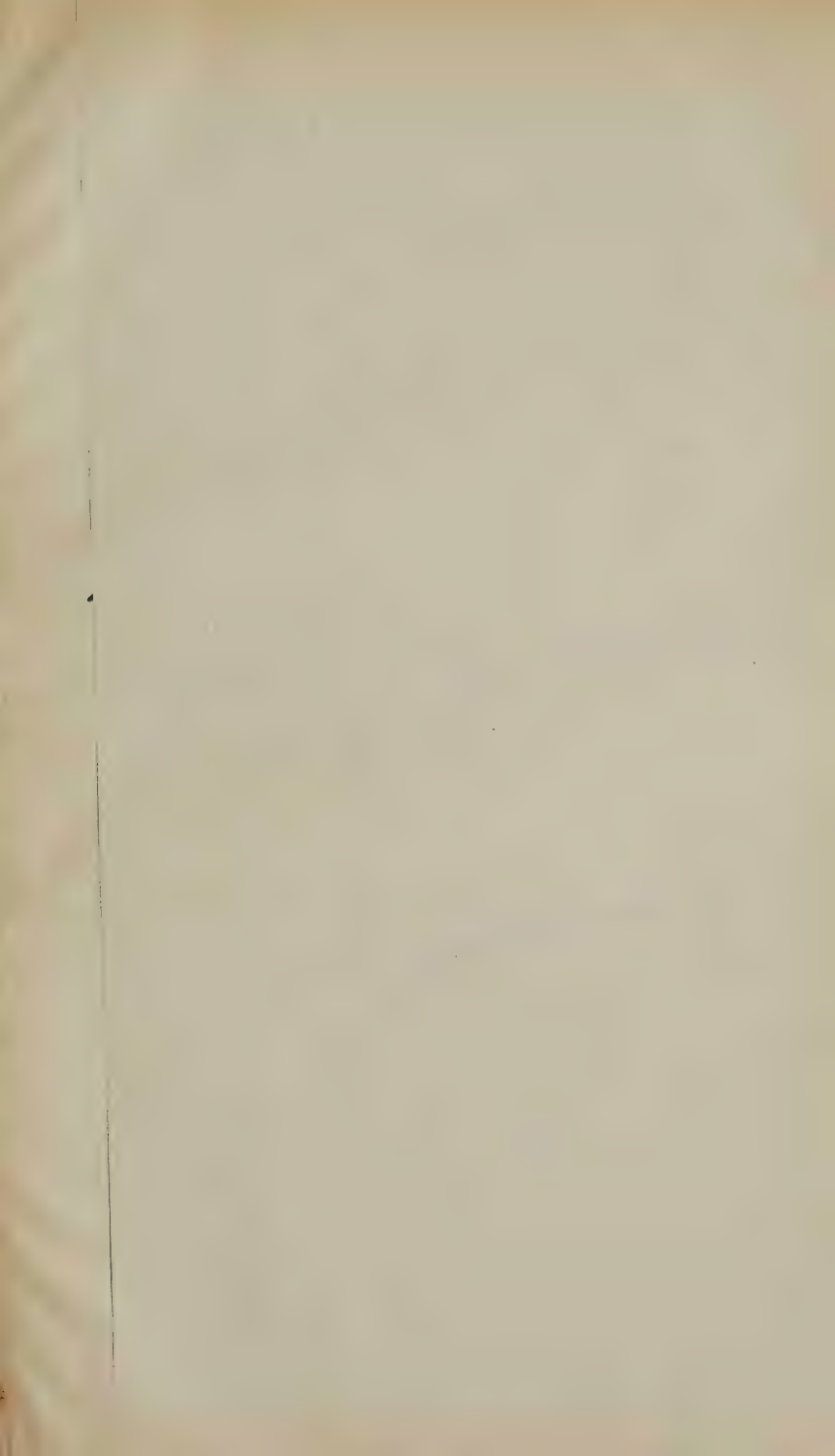
(or $\frac{1}{3}$ of the offset D C from the tangent for a chord equal to half the transition curve and radius R).

Position of point G is found thus :—

$$I H = (R + \text{shift}) \tan. \text{ of } \frac{1}{2} \text{ intersection angle} \dots\dots\dots (4)$$

Set off H G = shift, at right angles. Tangent lines parallel to the original ones are used for the circular arc which is begun at C.

To find C, A E is assumed equal to A C, H G and H A are set off equal to $\frac{1}{2}$ transition curve, then the offset E C = 4 times H G.(5)



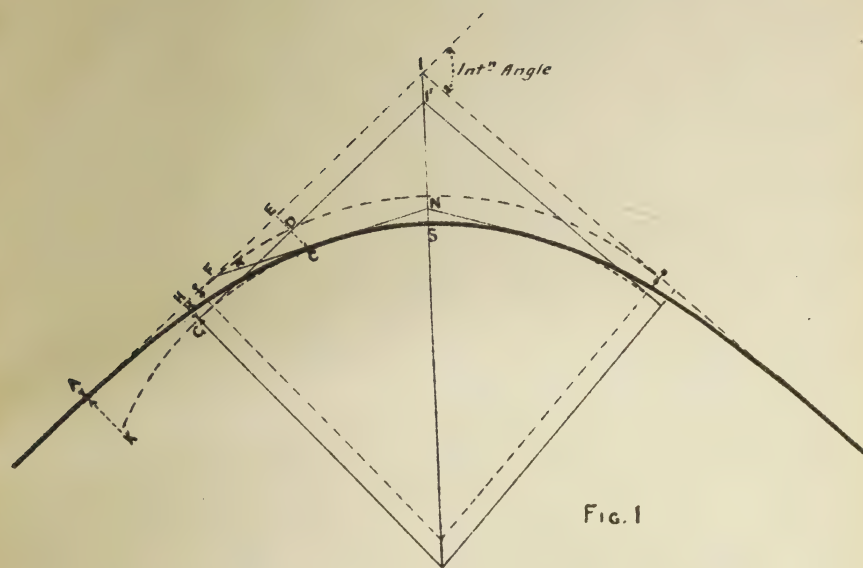


FIG. 1

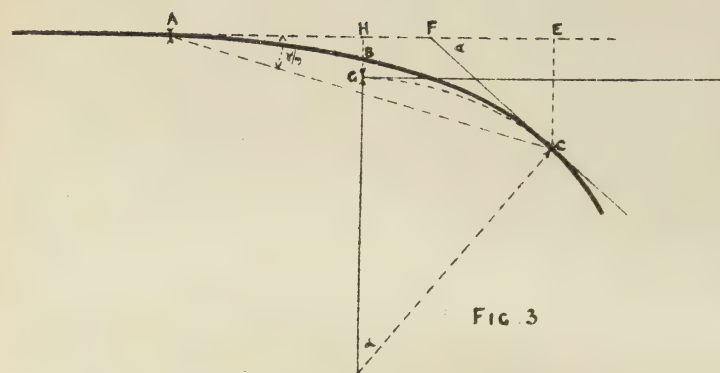


FIG. 3



FIG. 4

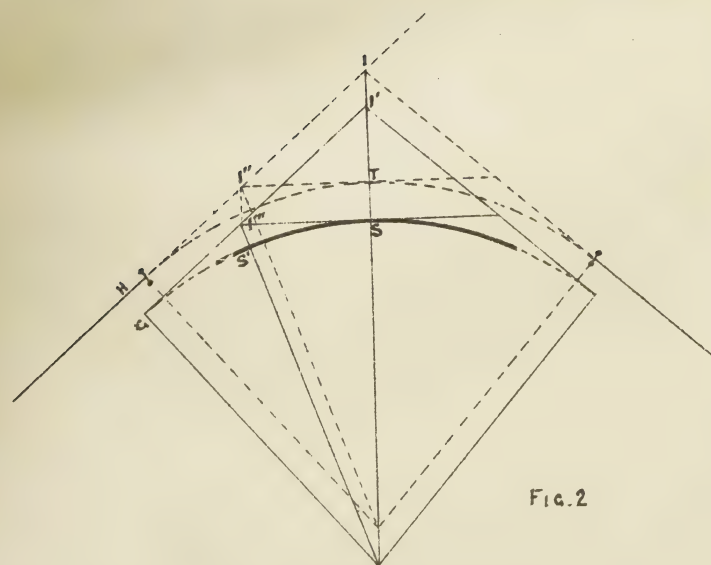


FIG. 2

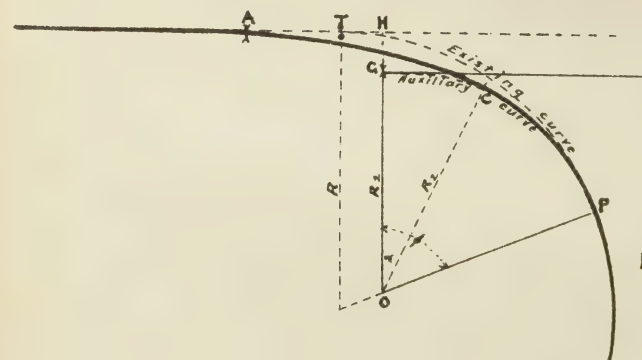


FIG. 5

The transition curve is set out by offsets from the original tangent line. Any ordinate at a distance x_1 from the point A $= \frac{x_1^3}{6 R x}$. (6) x being the length of the transition curve, and the denominator $6 R x$ becoming a constant for each curve. The offset H F must from equations (5) and (6), be $= \frac{1}{2}$ shift and $\frac{1}{3}$ E C.

From the equation referring to the ordinates (6) the cubic parabola received its name because the offsets vary as the *cube* of the distance from the beginning.

In addition to the above, which give all the data required, the new intersection point I' should be found and marked for future use. The internal angle is halved and I I' set off $= H G \times \sec.$ of $\frac{1}{2}$ intersection angle. From this new intersection the crown peg S' can be located.

If the curve is cut up by a sub-tangent the intersection I'' (see Fig. 2) can be found thus:—Set off at right angles to T I'' the length I'' I''' equal to I I'. The crown peg S' can now be found in the ordinary way.

On investigation it will be found that the curve as set out above begins at A with so large a radius that it can be practically considered as straight, and that the radius diminishes till it becomes at C equal to that of the original circular arc. This form of transition curve should, for these reasons and on account of the simplicity of the setting out, commend itself to engineers who are not conservative.

Rankine sets out the original curve first, and then transfers it nearer to the centre by the amount of the shift (hence the term). The transition curve is then set out by ordinates from the new position of the arc, beginning at C instead of at A. As Rankine uses for an example the case of reverse curves of different radii meeting without any straight between them, it is difficult to understand what is proposed for the junction of a curved and straight portion; in fact, the writer has after careful study failed to find the method for reverse curves possible. However, half of the transition curve can be set out by ordinates from the circular arc starting at C, using the formula (6), and if the arc be continued beyond the tangent point to K the other half can be set out. Strange as it may seem, and a fact worth noting, this method gives a curve identical with that fixed by ordinates from the straight.

It has been found that a tangent to the arc at C (Fig. 1) meets the straight (produced) at F and A F $= \frac{2}{3}$ of the length A E of the transition curve. Tan. angle $a = \frac{x}{2 R}$ (or, more exactly, twice

the tangential angle for $\frac{1}{2} x$ with radius R). From this a new tangent line F N could be located for setting out the circular arc, but would not prove so simple as the parallel tangent lines suggested previously. Should a exceed $24^\circ 5'$ (which is not likely) the cubic parabola instead of increasing in curvature as it gets

farther from the point A will, after a given distance, decrease, so that a limit to its length is imposed. When curves in opposite directions are set out sufficient length of straight should be provided between them to allow for the two halves (not necessarily equal) of the transition curves required by the circular arcs. The writer is unable to suggest a method by which two reverse curves with a common tangent can be united by transition curves.

The cubic parabola can be readily ranged with the theodolite by tangential angles. The instrument is set up at A. The angle for the whole length up to C is $\frac{1}{3} a$ (Fig. 3) and dividing the whole length into n parts we get for

$$\begin{aligned} \text{1st angle } & \frac{a}{3 n^2} \\ \text{2nd " } & \frac{a \times 2^2}{3 n^2} \\ \text{3rd " } & \frac{a \times 3^2}{3 n^2} \\ & \dots\dots\dots \\ \text{Last " } & \frac{a \times n^2}{3 n^2} \text{ or } \frac{a}{3} \end{aligned}$$

the angles varying as the *square* of the distances from A. It will be noted that the offsets these angles will give for their respective distances are the same as those given by formula for ordinates.

The curve may also be set out with the chain by offsets from the chord (see Fig. 4) :—

$$\left. \begin{aligned} a &= \frac{(\frac{1}{6}) \text{ chord }^2}{n R} \\ b &= \frac{(1) \text{ chord }^2}{n R} \\ c &= \frac{(2) \text{ chord }^2}{n R} \\ d &= \frac{(3) \text{ chord }^2}{n R} \\ e &= \frac{(4) \text{ chord }^2}{n R} \end{aligned} \right\} \begin{array}{l} \text{offset from tangent.} \\ \\ \\ \text{Deflection offsets.} \end{array}$$

R being radius in ft. and n = number of points. This method may, however, lead to serious cumulative errors.

An attempt has been made to ease the curves of *existing* lines at their tangent points, and introduce the cubic parabola, but the length from the start to the osculation with the curve is so great (including an angle of over 34° on each side of the tangent) as to preclude its use, there being also a point on it where the *least* radius of curvature is only 86 per cent. of that of the existing curve. If an auxiliary curve of less radius inside the other be introduced (see Fig. 5) the difficulty is partly overcome much in

the same way as the platelayers deal with it. Assume a radius for the auxiliary curve and solve the transition curve for that radius. To obtain P find angle ϕ

$$\cos. \phi = 1 - \frac{\text{shift}}{R - R_2};$$

from this find length G P. To find G, T H = $\sin. \phi \times (R - R_2)$. It will be seen that the *smaller* the radius of the auxiliary curve is made the *shorter* the length of line to be altered.



7.—PHOTOGRAMMETRY.

By CHAS. HOPE HARRIS.

* Photogrammetry may be defined as the practice of plotting the positions of various points in a landscape to scale upon a plan, by intersection of angular lines taken from two or more stations previously fixed with sufficient precision to serve as base lines for the plan to be prepared, or which shall be fixed during progress of the work by chainage of a single line.

The principles which form the basis of this science belong to trigonometry and perspective, and their application is simple to anyone accustomed to plotting with a protractor or scale of chords. The angles contained between various points visible in a landscape may be obtained from a photograph of them as accurately as required for the purposes of mapping, provided the lens used is of suitable construction, and attention is paid to the general rules hereafter laid down for securing satisfactory results.

The photographic angles just referred to are always too large to suit the spot at which the view is taken. There is a point for which they are all true, though its situation is by no means evident to the uninitiated, as it depends principally upon the focal length of the lens employed. Out of doors it occurs between the camera and the objects viewed, yet in the print lies from 4in. to 10in. below the middle, upon a line dividing the picture equally left and right. This state of things may be expressed by the following formula:—The tangent of the photographic angle, divided by the focal distance between the lens and the plate, gives the tangent of

the true angle; or $\tan. A = \frac{\tan. a}{F}$. This ratio of the tangent explains how it is that the parts of a building near at hand seem to be represented disproportionately larger by the lens than others more remote.

* The term "Photogrammetry" was an outcome of a convention held on the Continent a year or two ago with reference to the subject. Effectual objections were made to every name suggested for the practice excepting to this one, which was tacitly acknowledged.

Angles are found from the photograph by the use of a pair of dividers, a scale, and a table of natural tangents. This may be done approximately with any photograph by ruling a line across the middle from left to right, and another at right angles to it, from top to bottom, called the co-ordinating lines. The intersection of these lines should correspond to the optical axis of the lens: and all angles derived from paper measurements taken parallel to the horizontal line left to right of the vertical one will, if the camera has been set up truly, be correct horizontal angles; whilst those derived from measurements above or below the horizontal line will be true angles of elevation or depression from the centre of the lens.

Two factors, however, are required before these angles can be worked out to correspond with what they would be if read with a theodolite placed where the camera stood. They are the offsets from the co-ordinating lines, and the focal length of the lens. Calling the offsets taken left or right of the middle P , P_1 , P_{11} , the offsets taken above or below the horizon line ($f+$) or ($f-$), the focal length F , and the required angle A ; the formula is

$\tan. A = \frac{P}{F \pm f}$; P , F , & f being of course taken in the same unit of measure; thus, let P as measured upon the negative = $\frac{30}{100}$ in., $F = 8$ in., $f = nil$, then $\tan. A = \frac{30}{800} = .0375 = \tan. \text{ of } 2^\circ 9'$. Again, if P be 4 in., $F = 8$ in. as before, and $f = 1$ in. above the line; $\tan. A = \frac{400}{900} = .4444 = \tan. \text{ of } 23^\circ 58'$. It may be

well at this point to remark upon the characteristics of various lenses in order to avoid being misunderstood, and to prevent disappointment to anyone who might attempt this kind of work with a lens ill adapted to photogrammetrical purposes.

The so-called single lens (which is really compound, and generally of a meniscus or new moon form) is good for ordinary landscape work, but not for architectural subjects, as when used with a stop in front of the lens the image of a square becomes barrel-shaped, but with the stop placed behind, it gives a cushion or hour-glass form.

Portrait lenses are constructed to give a brilliant image of objects in one plane only, and should not on any account be used for the purposes discussed in this paper, where the great desideratum is a common focus for near and distant objects. These conditions are fulfilled by the rectilinear or symmetrical lenses. They are doublets, and consist of two single meniscus glasses placed at a suitable distance apart, with their concave surfaces inwards and the stop between. We thus have a combination with the lens in front of the stop, giving cushion-shaped distortion, and the second similar lens behind the stop, giving barrel-shaped distortion to an equal extent. It follows that one distortion

neutralises the other, and the result is that even with a large aperture there is practically no distortion of any kind, and the alteration of focal length required to give sharpness of definition to an image comprising near and distant objects is only about $\frac{1}{8}$ in., and may be restricted to narrower limits. If the middle distance be sharply focussed the greatest error of focal length will usually be about $\frac{1}{16}$ in.

In determining the focal length of a rectilinear lens by a method published by Mr. Grubb, the writer recently adopted the following course:—Two points about half a mile away, subtending a suitable angle for full width of a picture, were focussed, and their distance apart, as seen on the ground glass screen, was measured and found to be 6 in., *i.e.*, 3 in. upon each side of the middle upright line. By means of the theodolite, placed over the same spot, the true angle was found to be $38^{\circ} 56'$. By solving the isosceles triangle thus formed with a base of 6 in., and with adjacent angles of $70^{\circ} 32'$ each, the distance from apex to base is found to be $8\frac{1}{2}$ in., which is technically called the equivalent focal length. This would answer sufficiently well if one were sure that the negative occupied exactly the same position as the screen, but as there was reason for doubting whether the above result really gave the correct factor required for a constant divisor or not, the following test was resorted to:—A photograph of the landscape at hand was taken, and, with a theodolite placed over the same spot, horizontal and vertical angles were read to prominent hilltops, gables, and trees that could afterwards be recognised upon the print for comparison with angles scaled from the negative or proof. Two calculations were made, as shown by Fig. 1—one by reference to a chimney, which by scale upon the picture was 3.15 in. to the left of the vertical line, and 0.30 in. above the horizontal line; the other by reference to a post on the horizontal line, and 2.37 in. to the right of the vertical line. The angles taken with the theodolite were $19^{\circ} 45'$ and $15^{\circ} 37'$ respectively. In the first place by trigonometry,

$$(F + f) = \frac{P}{\tan. A}$$

Left hand offset 315 log.	2.49831
Angle $19^{\circ} 45'$ log. tan.	9.55513
	<hr/>
$(F + f) = 877 \log.$	2.94318

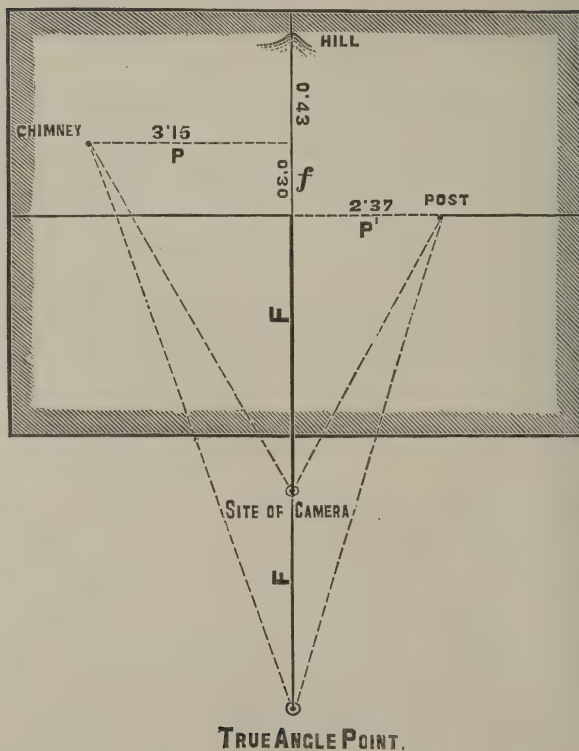
Then subtracting f , = 0.30 in, we have $F = 8.47$. In the

second case, by trigonometry, $F = \frac{P}{\tan. A}$

Right hand offset 237 log.	2.37475
Angle $15^{\circ} 37'$ log. tan.	9.44641
	<hr/>
$F = 848 \log.$	2.92834

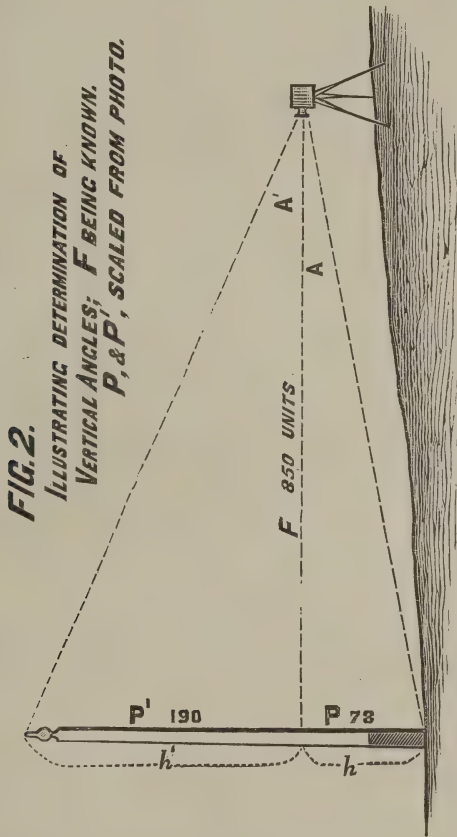
Thus the working focal length of the lens is 8.475in., or nearly 8½in. Several horizontal angles were determined from the photo. with this factor, and they agreed within a few minutes, more or less, with those taken with the theodolite. The angle of elevation to a prominent hill was also found, as follows:—Height above horizontal line = .63in.; divided by focal length, 8.475in., gives tan. of $4^{\circ} 15'$, only a minute different from the observed angle.

FIG. 1.
ILLUSTRATING DETERMINATION OF
HORIZONTAL ANGLES; F BEING KNOWN.
 P, P', f , BEING SCALED
FROM PHOTO.



The simplest application of photogrammetry to vertical angles is to determine the height of a telegraph post from a photograph,

concerning which the following particulars are obtained. Camera upright; focal length, $8\frac{1}{2}$ in.; and horizontal distance from middle of lens to post, 68 ft. 9 in.*



By reference to the accompanying wood-cut it will be seen that the space between the horizontal line and the ground scales 78 units, and the space from the same line to the top of post 190 units. Thus there are two sides of two right-angled triangles from which to find one angle of elevation, and one of depression.

* Measured with a tape, for calculating height of post after the angles have been found.

The calculation is as follows:—Tan. angle $A = \frac{P}{F}$; tan. angle $A' = \frac{P'}{F}$

(P) scaled from photo = 78; log. = 1.89209

(F) focal length of lens = 850; log. = 2.92942

$$A = 5^{\circ}15', \text{ log. tan. } \underline{\underline{8.96267}}$$

(P) scaled from photo, 190; log. 2.27875

(F) focal length 850; log. 2.92942

$$A' = 12^{\circ}36'; \text{ log. tan. } \underline{\underline{9.34933}}$$

Having obtained both the angles, now substitute the measured base 68.75ft. for the focal length F, and find the two perpendiculars, as follows: $h = \tan. A \times D$; $h' = \tan. A' \times D$.

(D) measured distance, 68.75; log. 1.83727

(A) calculated angle, $5^{\circ}15'$; log. tan. 8.96267

$$h \text{ in feet} = 6.31; \text{ log. } \underline{\underline{0.79994}}$$

(D) measured distance, 68.75; log. 1.83727

(A') calculated angle, $12^{\circ}36'$; log. tan. 9.34933

$$h' \text{ in feet} = 15.36; \text{ log. } \underline{\underline{1.18660}}$$

6.31 feet below axis of lens

15.36 feet above axis of lens

21.67 feet, total height of telegraph post

Or for brevity put h , and h' for heights of portions of post,

$$\left. \begin{aligned} \text{then } h &= \frac{P}{F} \times D \\ h' &= \frac{P'}{F} \times D \end{aligned} \right\} \text{ and } h + h' = \text{height.}$$

In order to try horizontal angles with a protractor upon the print it is necessary to produce the vertical line to a point below the horizontal line exactly equal to the focal length, which in this case is 8.475in., where they will be found to agree perfectly. This important position may be called the "angle point." It is also the point of station with regard to true geometrical perspective of the whole picture.

If the camera be moved about a quarter of a mile and the distance measured, another photograph of the same view will supply data for plotting with accuracy every object that can be

clearly seen in it; the liability of error, judged of by tests applied to my experiments, being about 1 per cent., viz., one chain in one and a quarter miles. It is evident, therefore, that the camera might be made valuable to the surveyor in furnishing him with reliable details where required for the compilation of topographical maps, especially for parts difficult of access. Architects and engineers might also find the application of photography upon these lines convenient and safe in many cases where at present they would not employ it, supposing that no reliance can be placed upon the results.

The writer is indebted to notes in the "Photographic Journal" of June, July, and December, 1892, for suggestions upon the subject; also to a paper in the Transactions of the American Mining Engineers for 1890, by Messrs. Flipper and Noagles.

NOTES AND REMARKS UPON ESSENTIALS OF PHOTOGRAMMETRY.

1. The focal length of lens used should be ascertained and recorded on the back of every plate required for photogrammetrical purposes. A permanent mark can be made on the camera at the average focus, and the small difference from the mark observed each time.

2. The camera should be placed level, that is, the sides should be upright and the top horizontal.

3. One horizontal and one vertical line should be drawn upon the screen, and the lens be adjusted so that its optical axis coincides with their point of intersection; then the carriers should have four studs corresponding precisely with the terminal points of the lines on the screen, which studs might be so arranged as to be photographed upon the margin of the negative, thereby indicating the exact position of the co-ordinating lines.

4. When photographing a building measure the distance from lens to a point on wall coinciding with the optical axis of the lens. The position of the point should be noted in a book, with the distance.

5. Instead of tilting the camera it is best to fit the lens into a slot so that it can be moved up or down an inch or two when required.

6. All offset distances should be scaled from prints that have not been toned or fixed, as they then perfectly agree with the negative, but shrink or expand unevenly after wetting.

7. The gelatine film of the negative, though it enlarges with chemical treatment, affords when dry the same dimensions of the luminous image it received when in the camera, the exact measurement of which, taken occasionally upon the ground glass, will be a convincing test of this.

8. Celluloid films are manufactured in America for use instead of glass, and afford a capital surface for working up field draughts upon.

8.—THE DESIGN OF TURBINES.

By B. A. SMITH, M.I.C.E.

(WITHDRAWN.)



9.—AN ARCHITECTURE RACY OF THE SOIL.

By M. F. CAVANAGH, A.R.I.B.A.

10.—A MEANS OF DISTRIBUTING OIL ON THE SURFACE OF THE SEA.

By THOMAS TURNBULL, A.I.M.E.

(ABSTRACT.)

The paper describes the author's attempts to devise some means whereby oil may be easily and efficaciously spread on the surface of the sea in rough weather. His efforts have resulted in an apparatus, consisting of a double cylinder of tin, or other light and strong material, made to slip over an ordinary ship's rocket. The annular space in the cylinder is $\frac{3}{16}$ in. wide; the top end of the cylinder is conical, with a diaphragm at the base of the cone, communication being effected between the cone and the annular space in the cylinder by means of perforations in the diaphragm. The diaphragm has a slight bulge in its centre, the convexity of which is towards the rocket. The lower end of the annular space is filled with a light plug or cap, on which are soldered two eyes, the latter being of such length that when placed on the rocket the plug does not foul the rocket's stick. The apparatus is used as follows:—An ordinary ship's rocket is taken and the head containing the stars and meal-powder is wrenched off, leaving the fuse exposed; a thimbleful of powder is placed over the fuse, and the double-cylinder, called the "carrier," which has been filled with oil (linseed oil preferably), is slipped over the rocket; the plug in the lower end is then made fast to the rocket stick by a wire or wetted cord. When the rocket is fired the composition eventually ignites the fuse at the point, which in its turn explodes the powder, and the gases of this drive the cylinder or "carrier" forward, leaving the lower end free for the discharge of the oil; the plug remains behind, having been attached to the stick. The action of the powder on the convex side of the diaphragm also aids the release of the plug by forcing the oil against it. The author states that he has, with an ordinary rocket, put the charge of oil 400 yards dead to windward in the teeth of half a gale.

11.—A FEW NOTES ON WATER TUBE BOILERS, WITH RESULTS OF SOME TRIALS ON A NEW FORM OF WATER TUBE BOILER.

By J. T. NOBLE ANDERSON, C.E.

PLATE XVIII.

The history of water tube boilers is much too long and of hardly sufficient interest to justify more than a few passing remarks on the present occasion. Almost simultaneously with the invention of the boiler as separate from the steam engine we find inventors advocating the use of water tube boilers. It is now more than 100 years since water tube boilers of the two standard types of to-day were first patented, namely, (1) boilers in which water jackets around or above the furnace were connected by water tubes situated across the fire, and (2) boilers in which coiled water tubes were situated in a firebox. Since that time the development of water tube boilers seems to have been effected chiefly in America. In Great Britain during the middle of the present century several boilers of this type were used, such as Gurney's, Perkin's, and Craddock's. Of these Perkin's boiler alone gained a permanent foothold on the market, being considerably used in boilers for fire engines on account of the rapidity with which steam could be raised in the water tubes.

A great point in favor of these boilers which helped to win the day in America was the immunity from serious accidents which is obtained by its use. Considering the national character, one is rather surprised that this point should carry more weight in America than in England, and the natural inference is that boilers of other types were constructed in a stronger and better fashion in England than in America.

The conservatism of the Briton is often compared unfavorably with the inventive boldness of his American cousins or the ingenuity of his continental neighbors. Much of the British conservatism is no doubt due to the thorough and workmanlike manner in which so many of England's mechanical achievements have been executed. The completeness and satisfactory results of such achievements make them difficult to vary, and render the manufacturer jealous of any alteration in his design. In America, on the other hand, being a new country, people are accustomed to many changes and too frequently adapt makeshifts. In consequence the character of their work is different. An English workman will make every link of his chain so strong that there can be no danger from its breaking; an American would prefer to begin by seeing his chain break, "just to know where it would go."

The following report is characteristic of American methods (it was made by a committee of the Franklin Institute on the Harrison boiler, November 12th, 1866):—"These boilers are of cast iron,

formed of a combination of hollow spheres, each 8 in. in diameter externally and $\frac{3}{4}$ in. thick, connected by curved necks $3\frac{1}{4}$ in. diameter. These spheres are held together by wrought-iron bolts, and in one direction are cast in sets of two or four with opposite lateral openings to each sphere, called by the inventor two or four balled elements, as the case may be. He assumes that the boiler, in its smallest form, may be considered as one of these balls with its opposite lateral openings closed by caps held in place by bolts. Two balls united by a neck with caps over the four lateral openings would make a boiler of the next larger size," &c. . . . "Any number of these balls or spheres may be united by bolts passing through them, so as to form large boilers. The strength of these boilers will be that of the weakest sphere in the structure. In manufacturing the boiler for ordinary use a number of these elements are so arranged as to form sections twelve balls long, six balls wide. These sections are all tested by hydraulic pressure as high as 300 lbs. per square inch before being delivered to purchasers. The committee saw one of these sections subjected to a bursting pressure of water, one sphere bursting when the pressure reached 600 lbs. per square inch. They were shown a section in which one unit had burst at 900 lbs. per square inch; the damage was repaired by the insertion of a new unit. The section then stood 1,100 lbs. per square inch before bursting in a new place. The available strength of the section in all cases being the strength of the weakest unit in it, the inventor holds that it is safer than any other in use," &c. . . . "To prove which he had a section equal to six horsepower, similar to the one tested by hydraulic pressure and such as he is regularly selling, placed in an extemporary furnace built in a clay bank and set in the usual manner for a boiler of this kind. The boiler was filled with water to the usual height—about two thirds full—and with no outlet or safety valve of any kind, sealed up tight, a small tube leading from the upper ball to a high-pressure gauge placed at a safe distance, about 200 ft., from the boiler; a fire was made under and around the boiler with dry firewood. The wind was very high at the time, blowing directly unto the furnace, thus fanning the flames to an intense heat. The pressure increased at a uniform rate until it had reached the enormous strain of 850 lbs. per square inch, when a sudden discharge of steam took place, seemingly no greater in volume than might issue from a safety valve of $2\frac{1}{2}$ in. diameter, after which the pressure fell to 450 lbs., at which it stood until the fire was drawn."

"November 13th, 1866—At 4 o'clock the committee met at the factory," and it was found that some bolts "had become slack."

This statement is taken from the "Journal" of the Franklin Institute, February, 1867. The "Journal" seems sober enough. Unluckily no particulars are given of how the pressure gauge was tested, and the committee seem to have failed to make the most of

their opportunity, since they do not give a more distinct description than this.

During the ten years following this great progress was made in American engineering; and during this decade the water tube boiler was evolved in the forms that have since enabled it to drive all other boilers almost entirely from the market in that country, so far as stationary work is concerned.

The following table is the result of trials at the Centennial Exhibition of 1877:—

Name.	Average Absolute Steam Pressure. Lbs. per sq. in.	Temperature (Fahr.).				
		Air.	Boiler Room.	Steam.	Up-take.	Feed Water.
Wiegand { Capacity trial ..	84.75	71.9	90.9	312	604	74½
Wiegand { Economy trial ..	84.77	69.4	85.53	313	563	70.80
Harrison { Capacity trial ..	84.63	77.8	91	308	584	71.3
Harrison { Economy trial ..	84.90	75.8	96	310	517	71.1
Firmenich { Capacity trial ..	84.77	74.7	91	358	418	68.9
Firmenich { Economy trial ..	84.56	69.4	83	356	415	69
Root { Capacity trial ..	84.68	61.8	72	312	393	63.7
Root { Economy trial ..	84.41	72.2	84.2	308	393	64.6
Babcock & Wilcocks { Capacity trial ..	84.62	63	90	305	472	57
Babcock & Wilcocks { Economy trial ..	84.75	41	86	289	295	64
Anderson { Capacity trial ..	84.58	56	56	320	534	54.7
Anderson { Economy trial ..	84.64	55	55	322	417	54

Table continued.

Name.	Quality of Steam.		Pounds of Com-bustible per Hour.	Pounds of Water Evapo-rated per Hour.	Equivalent Pounds of water per Hour Reduced to Evapora-tion from and at 212°.
	Percentage of Moisture.	Number of Degrees Super-heated.			
Wiegand { Capacity trial...	.810	—	613.9	4772.2	9.145
Wiegand { Economy trial..	—	20.52	469.5	4311.7	10.834
Harrison { Capacity trial...	2.072	—	378	3170	9.889
Harrison { Economy trial..	.935	—	260.1	2410	10.930
Firmenich { Capacity trial...	—	9.06	213	1994	11.064
Firmenich { Economy trial..	—	32.63	166	1685	11.988
Root { Capacity trial...	—	43.63	490.7	4315	10.441
Root { Economy trial..	—	41.35	341	3485	12.094
Babcock & Wilcocks { Capacity trial ..	.94	—	622.8	5390	10.330
Babcock & Wilcocks { Economy trial..	2.67	—	395.5	3939	11.822
Anderson { Capacity trial...	.307	—	478.4	3826	9.568
Anderson { Economy trial..	—	15.66	318.4	2823	10.618

Since that time the efficiency obtainable has been but little improved upon, but many improvements have been introduced, chiefly in the direction of economy and strength of construction. It is reported that several of the water tube boilers at the present Chicago Exhibition are capable of giving results close on 13lbs. evaporation per pound of nett combustible with coal. Unfortunately no results such as this can be made for comparison with those just quoted, because the fuel used is in every case liquid fuel. It is a noteworthy fact that every boiler which is in use at the Chicago Exhibition belongs to the water tube type.

Mr. George Barrus, in a book on boiler tests (1891), gives, as the result of seventy-one boilers tested by him, the highest place to a water tube boiler with an evaporation of 13·01lb. Turning to Europe we find the Belleville boiler in favor in France about thirty years ago, and from that date till now a great number of different water tube boilers have come into favor, among others the D'Allest, the Normand, and the Du Temple.

Here it is remarkable that this type of boiler has been almost exclusively used in the naval and merchant marine, as will be more fully explained elsewhere, while in America and other countries where the water tube boiler is in favor it has been excluded from marine service, with the exception of the torpedo boilers, such as the Mosher in America and the Yarrow and Thornycroft boilers in England, these being adopted on account of the small grate area with light weight and the advantage of safety they offer in action, but they are far from economical in first cost or maintenance.

In Germany the types of boiler which have been used for many years (*e.g.*, the Tenbrink) would naturally lead to the water tube, and, with the exception of America perhaps, there is no place where it has been more universally adopted.

At the recent Frankfort Exhibition all the steam was raised in boilers of this type.

In England, where these boilers* have been long discredited, they are steadily gaining in favor, and are now much used for electric lighting; and even the Admiralty are moving from their stolid conservatism so far as to institute comparative trials between torpedo boats fitted with water tube and fire tube boilers, and, more wonderful still, have decided that the new torpedo catcher "Speedy" is to be fitted with Thornycroft water tube boilers.

So rapidly have the new forms of water tube boilers developed that it is not easy to follow the evolution of each, and class it accordingly. In a broad way we stated at the beginning of this paper that there are two main classes—(1) boilers in which water jackets are connected by water tubes. To this class belongs each of the following excellent types:—The Heine (a very efficient and cheap boiler), the Lagrafel D'Allest (the favorite boiler in the

* The writer does not call an internally fired boiler fitted with galloway tubes "a water tube boiler."

French navy), and the Shann boiler to be described hereafter, and torpedo boilers : in this last case the connection seems at first sight to be with the spiral tubes, but by looking at the Yarrow boiler it will be seen that the lower water drums, though cylindrical in form, are really identical with the "water jackets" or "waterlegs," which distinguish all boilers of this class. (2) Boilers consisting of coiled water tubes : It is not clear how spiral boilers are connected with such boilers as are called sectional by their manufacturers. If, however, we flatten a spiral into a sort of gauche zigzag figure we get something resembling the elements of a Belleville boiler ; and it is not a far step from this, with its series of pairs of headers, to the Babcock & Wilcocks boiler, with its sections, each containing two continuous headers, and forming a connecting link, as it were, between the first type and this latter type, since in turn each section might be considered as a separate boiler.

The writer first had his attention turned to these boilers some fourteen years since by a relative who had patented a new type of marine boiler, which was to be a combination of the water tube and fire tube boiler, but it was not until July, 1891, when he had occasion to travel from Melbourne to Marseilles in the M.M.S. *Poly-nésien* that he fully learnt the advantage of boilers of the water tube type for marine purposes. On the voyage the weather was unusually adverse, a heavy head sea running until the Red Sea was reached, and as the captain was disappointed in getting coal at Aden the chief engineer was forced to use every possible economy until Menzaleh was reached ; there sufficient coal was taken on (15 tons) to enable the ship to go through the canal. The writer was horrified to hear that one of the modes of economising fuel was to dispense with the evaporator used for making up the feed and make up with sea water. The engineer-in-chief explained that owing to their system of mixing milk of lime with the hot feed the salts in the sea water were almost all deposited in the separator, which is an important part of all marine boilers of the Belleville class.

This explanation did not agree with the writer's preconceived ideas of the chemistry of this subject, so he made a point when at the ship building and repairing yards of the company at La Ciotat to get further information.

He was there shown water tubes which had been removed from marine boilers after six or seven years' service, and the iron (they were of lapwelded wrought iron) was coated internally by black oxide, which formed a smooth coating. This was due to the formation of very greatly superheated steam on the surface where the water was in contact with very hot metal. This coating not only protects the pipe, but it will be readily seen that where steam is being so rapidly generated there is not much danger of incrustation or deposit, and consequently salt water feed can be used with impunity.

The boilers in the Messageries packet boats are worked at a pressure of 180lbs. per square inch, and there is no inconvenience such as has been experienced in almost every large boiler in the British Navy from leaking of the tubes where they are connected with the tube plate, when the boiler has been forced. On the contrary, the behaviour of water tube boilers when pressed is remarkable, and in this respect at least they far surpass all other types. The table already given (page 605) will show that in no case could the boilers be said to have primed when under their capacity trials.

There are, no doubt, still many places where fire tube boilers will be found more suitable than water tube boilers, but sufficient has been said to show how much more these boilers are being used than they were some years since. The objections raised against this boiler were as follows :—

(1) It is too costly.

(2) It requires frequent overhauling for repairs owing to the number and complexity of its parts.

(3) It is troublesome to clean, being inaccessible in parts.

(4) Its circulation is defective.

(5) It is too weak to stand much wear and tear.

(6) It is liable to leak owing to the large number of joints.

(7) It occupies an exceedingly large space.

(8) It is not economical in fuel.

In answer to these objections :—

(1) Most water tube boilers are more expensive than other boilers of the same capacity at the manufacturers' yard, but when the boiler has to be transported any distance, and perhaps erected in an inaccessible place, it often costs the owner less when erected.

(2) Well-designed water tube boilers do not require to be repaired more than once in two or three years, and then the repairs are slight, and can be effected without much trouble and in a short time.

(3) If the circulation be at all uniform it is so rapid that the boiler is self-cleaning.

(4) In a well-designed water tube boiler the circulation should be better than in any other boiler.

(5) To withstand the same steam pressure a water tube boiler may be many times lighter than any other type, and consequently is not subject to the same racking or straining; in fact this is a point also in which, if properly designed, a water tube boiler should be superior to any other type.

(6) There is no inherent reason why the joints should leak any more than other water joints, and it has *not* been found that this is a source of trouble; some joints often leak when the boiler is cold which, however, soon become tight owing to expansion when the steam is being formed.

(7) The heating surface is certainly greater in proportion to the grate area than any other boiler, except the locomotive boiler, but it can be contained in a compact volume.

(8) The records of trials already given will show that this contention is false.

These stupid objections would not have been recorded were it not that the writer is continually hearing them. In a paper recently read before the Institution of Naval Architects, Mr. J. T. Milton, chief engineer surveyor to Lloyd's Registry of Shipping, sums up the advantages of the water tube boiler as follows:—

It gives (1) "the means of obtaining higher working pressures than are practical with other boilers, owing to the excessive thickness of plates which would be necessary both for shell and also for the heating surfaces."

(2) "Economy of maintenance due to the comparative ease with which, in some designs, every part of the boiler, both external and internal, can be examined and cleaned, and, if necessary, renewed, it being with some types possible to entirely re-boiler a vessel without opening decks, &c."

(3) "A decrease of space required and also of weight of boilers and accessories necessary for producing a given power obtainable with a given weight and in a given space."

(4) "It is also generally claimed for all classes of water tube boilers that they are less liable than ordinary boilers to derangement or damage through accident or neglect, and also that, even in the case of rupture, the damage which would result would be less than with ordinary boilers, owing to the much less quantity of water which they contain."

Then, with reference to the important question of durability, he says, "It is well known that few have become worn out in less than ten or twelve years, when treated with ordinary care, while many cases are within our knowledge of such boilers being now in use after twenty years' service."

It will be seen from this that almost all the factors that go to make up commercial economy will tell in favor of the water tube boiler for use in the marine. It allows—

(1) Of high working pressures and consequent coal and water economy.

(2) It is cheap to maintain and can be easily renewed.

(3) It takes up less space than other boilers; consequently its price should be credited with the saving in cargo bunkers, which factor alone would repay a considerable first cost.

(4) It is safer to work with. (And we might go on to add some points which have been brought out in the former part of this paper.)

(5) Salt water can be used in the feed with impunity.

(And in the case of the Shann boiler, at least,)

(6) The first cost is less than that of any other boiler of the same size; and

(7) It is a great advantage, especially in the navy, to have a boiler which can on occasion be pressed to give nearly double its normal capacity.

All of the above-recited advantages, especially the last, fit this boiler, also for electric power or light service where the demands on the plant are often made without notice, and consequently a boiler which has a good efficiency both when working under its true power, and when pressed far beyond its true capacity, is required; and also, as electric stations are usually in crowded centres where real estate is expensive, it is just as important that the boiler should occupy the minimum space as it is on board ship. The result is that *all* the large electric companies recommend water tube boilers and supply no others. The same reasons should make hydraulic power companies also give them the preference.

Professor Kernot and the author conducted some trials of a water tube boiler, patented by Mr. Montague H. Churchill Shann and erected by him, in the boiler-room at the Parliamentary electric light station, Melbourne.

The following is the tabulated records of these trials:—

APPENDIX No. 1.

Record Table of Trials of Mr. Montague Shann's Boiler at Parliamentary Electric Station, Melbourne.

Date.	Pressures.		Temperatures.					Notes.	Weight.
	Steam Absolute.	Draught.	Air.	Room.	Flue.	Feed.	Steam.		
1893.		in.	°	°	°				lbs.
June 19..	130	$\frac{1}{8}$	50	54	620	50·8 52	—	400lbs. steam per hour	112·8
June 21..	128	$\frac{1}{8}$	51	60	1000	53	480	800lbs. steam per hour	896
June 21..	98	$\frac{1}{8}$	47	62	460, 1380	53	390	650lbs. steam, 19 electric arc lamps, re- duced to 12 during latter part of test	595
Sept. 15..	93	$\frac{1}{8}$	54	61	592	58	—	550lbs., 109 incandescent lights run- ning	599

Appendix No. 1—continued.

Date.	Weights.			Actual Evapora- tion per lb. Combustion.	Evaporation Re- duced to, from, and at 212°.	Remarks, Duration of Trial, &c.
	Feed.	Ashes.	Clinker.			
1893. June 19 ..	lbs. 806	lbs. 43	lbs. 20	—	9 08	Steam raised to 118lbs. pressure by gauge in 1hr. 15min. from lighting fires. Trial lasted 2hrs.
June 21 ..	4762	105½	55.5	6.71	8.6	Capacity trial. Calorimeter showed the value of each lb. steam as 1237 B.T.U., allowance of 5 p.c. made for moisture in coal.
June 21 ..	3240	not separated		6.74	8.35	Calorimeter gave value of 1lb. steam as 1213 B.T.U. Allowance of 5 p.c. per moisture in coal. Trial, 6hrs.
Sept. 15 ..	3340	—	93	6.69	8.25	Trial lasted 6hrs. Calorimeter read twice—1228 B.T.U., 1231 B.T.U.; gave an average, 1229 B.T.U.

During these trials a log book was kept, in which records were entered at least once every fifteen minutes. The weighbridge on which everything was weighed was by Avery, and accurately tested. The thermometer was also accurately calibrated. The pyrometer was by Bailey; it has not yet been tested; when it was reading 1300°, Fahr., it was examined and found to be a dull cherry red; hence it is probably nearly correct for high temperatures. Calorimeter readings were taken in a barrel of about 40galls. capacity, and the temperature of the steam was taken from the steam pipe leading to the steam engine. Unfortunately the connecting nipple was so placed that it rapidly filled with condensed water, and consequently the reading was certainly below the true temperature of the steam. The engine was by Marshall, but was not only of an old type, but had very poor steam connections so that quite 40 per cent. of the steam was wasted. All the coal used was carefully weighed by two observers, and the water was measured by two accurately proportioned tanks. The trials were of an exceptionally severe nature (similar to those carried out by Sir Frederick Bramwell and Sir William Anderson for the Royal Agricultural Society in England), the fuel being raked out of both grate and ash pit before and after each trial, so that the record began with clean bars and left off under the same condition. It is not easy to get any record

results of boilers of the same capacity for purposes of comparison, and it obviously is unfair to compare the boiler with a larger boiler.

Sir Frederick Bramwell has estimated that the loss due to radiation in a large boiler is often less than $3\frac{1}{2}$ per cent., while in a small boiler he found that this loss increased to $16\frac{1}{2}$ per cent. of the total amount of heat produced by the consumption of the fuel. In these experiments the writer took careful readings of the temperatures around the boiler, and estimated that the loss from this source was not less than $7\frac{1}{2}$ per cent. On this account, making comparison with other boiler performances, it will be fair to calculate the efficiency of this boiler by comparison with the furnace efficiency. This is the usual mode of calculating boiler efficiencies. The formula generally adopted to find the furnace efficiency is taken from Rankine.

$$E_1 = E B \div (1 + \frac{A}{S} F)$$

Where E_1 = furnace efficiency in lbs. of water evaporated at 212° equivalent to each lb. coal consumed

E = evaporative value of fuel in the same measure

S = ratio of total heating surface to total grate area

B = .92 (arithmetical constant)

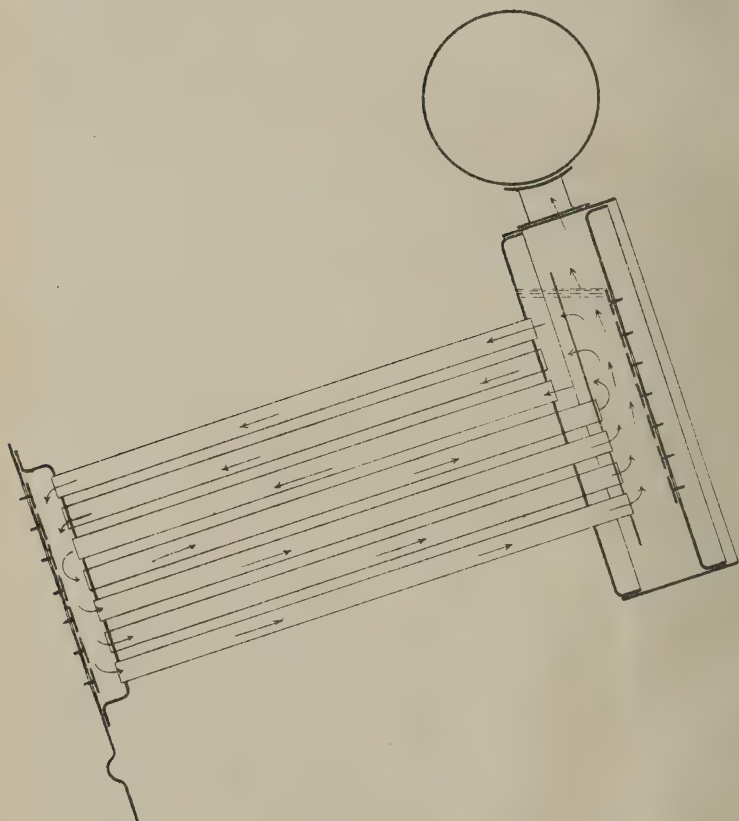
A = .5 (arithmetical constant).

In these tests the value of E , found when the boiler was tested to its utmost capacity, as in trial No. 2, works out as 7.63lbs., whereas the result actually obtained without making any allowance for ashes and clinker, which were drawn from the fire hot, nor estimating moisture in full, works out as 6.78lbs., showing the boiler as having the remarkable efficiency of 88.1 per cent.

The locomotive boiler gives almost as high results as can be obtained with any boiler of ordinary types. The trials on the Victorian railways show the evaporation when using the same fuel as 9.4lbs. Making allowance for the difference in size of boiler and consequent efficiency of furnace, it will be seen that the result gained with the Shann boiler is much better, and then it has further to be remembered that in the locomotive boiler there is considerable waste of steam power due to the forced draught, which loss helps the apparent evaporative result. In addition to this allowance should be made for moisture in the steam; this, in the absence of calorimeter tests, may reasonably be assumed to reduce the result to 8.5 lbs. evaporation.

In making these comparisons the writer has carefully avoided any assumptions which might seem too favorable to the water tube boiler. In the matter of radiation his assumptions are hardly so high as his observations would warrant, but he purposely avoids any circumstance which might give too favorable an impression for fear too sanguine anticipations might not be fully realised when this boiler came to be tested on a larger scale. Even should this

THE SHANN BOILER



boiler fail to attain the high efficiency which its inventor justly anticipates, the accompanying trials show clearly that as it at present exists it is a distinct step in advance of anything which has yet been effected. In general design it follows the Heine boiler, only that the tubes are placed at a considerable inclination in the fire, and the front header is divided by the division plate. The essential difference is not so much in this plate as in the fact that the circulation is in a complete cycle through the tubes and the two end headers or water jackets. In this connection it is well to point out that in most other water tube boilers the steam drum contains a large quantity of water which shares the circulation, through the tubes being connected with both front and back headers; in consequence there must be a considerable impeding of the current through the tubes, as will be readily understood by considering the very small head to cause flow through these pipes from the variations in density of the water in different parts of the water drum.

In the Shann boiler the circulation is quite beyond all precedent, and this can be readily understood since the only impediment to the free flowing of the water under the influence of the steam which rapidly forms in every part of the tubes is the *vena contracta* at the entrance to the tubes. The arrangement of the tubes is such that the hottest part of the fire receives the down draught of the water, which returns through the upper tubes after it has delivered its steam at the division plate; this will be clearly seen by the accompanying diagram (Plate XVIII.).

APPENDIX No. 2.

Table showing Dimensions of Boilers to accompany Record of their Performances.

Name.	Grate Area.	Heating Surface in Square Feet.			Draft Area.
		Water.	Steam.	Total.	
	Sq. ft.				Sq. ft.
Wiegand	42	1289·7	49·67	1339·37	5
Harrison	23	627	274	901	6·5
Fermenich	15·4	1001	30	1031	3
Root	42	1451·7	146·6	1598·3	5·04
Babcock	44·5	1676	—	1676	9
Anderson	36	630	485	1115	11
Shann	5*	106	{ 0 1	{ 106 108 }	·8†

* Grate area was varied in trial No. 4.

† A large quantity of cold air was admitted above the fire in all these trials. This circumstance must have injured the results considerably, but owing to the nature of the fuel it seemed unavoidable.

Appendix No. 2--continued.

Name.	Ratios.		Water Space.	Rating by U.S. Rule— 30lbs. Steam at 70lbs. Pressure per H.P. Hour.
	Heating Area = Grate Area.	Draft Area Grate Area.		
			Cub. ft.	
Wiegand	31.9	.119	181.3	{ Mean, 143 Max., 159
Harrison	39.1	.284	54	{ Mean, 80 Max., 105
Fermenich	66.9	.195	145	{ Mean, 56 Max., 66
Root	38.0	.120	116.6	{ Mean, 116 Max., 144
Babcock	37.6	.202	329	{ Mean, 131 Max., 179
Anderson	30.9	.300	67	{ Mean, 94 Max., 127
Shann	21.2	.160	16	{ Mean, 14 Max., 28

Accompanying this appendix is a transverse section through the water jacket and tubes of the Shann boiler.

Steam users are well aware that there are many factors which must be considered before pronouncing a boiler economical or otherwise.

Many of the most efficient boilers are but little used owing to their exorbitant first cost. To form an opinion of the relative cost of the Shann boiler and another favorite and economical boiler the writer paid a visit to one of the leading firms in Melbourne and got quotations for a boiler of the same rating as that just tested; the quotations were more than twice the price Mr. Shann informed him that his boiler had cost, and, further, when the boiler was delivered to the purchaser he would have the expense of building it in an elaborate brick seating. This boiler also would weigh two and a half times as much as the former, and would not admit of being forced to a greater extent than 50 per cent., whereas the Shann boiler can easily be forced beyond 100 per cent. without any diminution in efficiency.

The second most important question is whether the boiler is economical in maintenance. Of course in a new type of boiler it is not easy to predicate exactly what the maintenance will cost. However, so far water tube boilers have not been found more expensive on this head than other boilers, and owing to its strong and well braced construction, which is sufficiently elastic to allow for any conceivable alteration from expansion, and to take up any jar or shock it may encounter, there is every reason to anticipate that his boiler will be cheap in maintenance. The third important

question is the economy in fuel. The trials show that the Shann boiler is as efficient in this respect as any of its size can be expected, namely, 88 per cent. of Rankine's value for furnace efficiency.

There are many other questions which come into prominence under certain conditions, such as the value of having a boiler which will give a good efficiency under continuous steaming for a long period of time. To ensure this condition the Shann boiler has been so constructed that it can be readily cleaned while under full steam. In this respect it is much superior to the existing water tube boilers.

The main problem of economy can be expressed roughly by the equation.

$$\text{Comparative cost} = P + 10 M + 20 C.$$

Where P = Capital cost (first cost) of boiler.

M = Annual cost of maintenance and depreciation on assumed life of boiler

C = Annual cost of fuel, assuming interest at 5 per cent.

One very important result of these trials has not yet been mentioned, namely, the efficiency proved better in proportion as the working pressure increased. The inference is that of all boilers this is the best type for producing high pressure steam, and in view of the extreme pressure of modern times, where it is imperative to obtain the maximum amount of power with the minimum expenditure, it is certain that the present low pressure engines will soon be superseded; in fact, in marine service they have already been superseded by higher pressure of from 150lbs. absolute.

The writer understands that Mr. Shann has designed a larger boiler with many improvements, among others a large heating surface in proportion to grate area, and a mode of baffling the hot gases between the furnace and the flue, both of which were proved to be important matters by trials Nos. 2 and 3. He has carefully avoided taking any interest in the design of these improvements that he might have the more weight and liberty in expressing his opinion on subsequent tests.

How a boiler may be improved by baffle-plates is shown by the following figures from Mr. Milton's paper, referred to above:—

Lagrafel D'Allest Boiler with Baffle-plates.—Duration of trials, 6 hours; weight of Cardiff coal consumed, 1,008 K; evaporation, 10,760 litres; efficiency reduced to from and at 212° , 12.48.

Lagrafel.—Duration of trials, 6 hours; weight of Cardiff coal consumed, 1,512 K; evaporation, 10,170 litres; efficiency reduced to from and at 212° , 7.78.



12.—ON A NEW FORM OF TELEMETER.

By G. H. KNIBBS, *Lecturer in Surveying, University of Sydney.*

The constructive features of a surveying instrument lately invented by Mr. J. Short, an instrument maker, of London, and called by him a "gradient telemeter level," are, so far as I am aware, novel in respect of their application to telemetry. I propose therefore to discuss the limitations, in regard to accuracy, of telemeters constructed on this principle, without adhering rigorously to the details of Mr. Short's instrument in its present form. As it now stands the instrument may be thus briefly described:—A large telescope, similar in all respects to that of an ordinary level, is attached, at an angle of less than 90° , to an axis, the revolution of which is, by an attached pointer, measured on a graduated circle set at right angles thereto. This axis rotates within a second one, carrying the graduated circle; but the two axes, instead of being concentric or parallel, as in a theodolite, are inclined at an angle equal to the before mentioned defect from 90° . This second and outer axis is made vertical in the ordinary way by means of a level tube, and the instrument is adjusted so that the sight-line is horizontal, and is in the plane containing the two axes when the pointer (or vernier) is at the zero of the circle. A needle compass is also fitted to the instrument for the measurement of directions.

With an instrument adjusted in the manner above defined, if the inner axis remain clamped, the rotation of the outer simply causes the sight-line to trace out a horizontal plane, as in the case of an ordinary level, and this is the condition maintained while the instrument is used merely as such. If, however, the inner or inclined axis is rotated the sight-line departs from the horizontal, continually increasing its slope until an arc of 180° has been turned, when it diminishes, becoming horizontal again at 360° . The circle therefore serves as a measure of the degree of slope of the sight-line.

The telemetric theory of the instrument may be thus stated:—If g denote the natural cotangent of a sloping line, so that g expresses its *grade*, as so many horizontal to 1 perpendicular, then the intersections (s) of such a line with a vertical one (*i.e.*, a graduated staff), horizontally distant b from the other terminal of the slope line (*i.e.*, the intersection of the inclined axis with the sight-line of the telescope) is b/g below a point on the vertical line level with the terminal; and, similarly, it is b/g' for a second intersection (s') of a line of the grade g' . Therefore the distance is given by the formula

$$b = \frac{g g'}{g \sim g'} (s \sim s') \dots\dots (1)$$

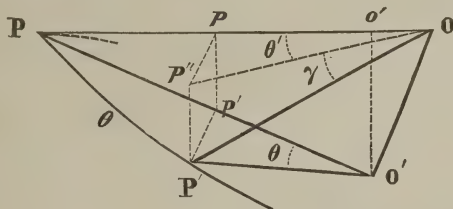
that is to say, the difference of the intercepts on the staff, when the pointer is set at specific grades, permits of the finding of the

horizontal distance. In this respect the instrument has, over the tachemeter type of instrument, the same advantage that is possessed by the omnimeter.

Any pairs of values of g that makes the factor $m = gg'/(g \sim g')$ a simple integer as 100, 80, 50, &c., are to be preferred for convenience. For example, if a staff be graduated to .01ft., the horizontal distance will be as many feet as there are hundredths in the difference of the staff readings, provided a pair of grades be selected such as will make $m = 100$.

With a view doubtless of facilitating in this way the use of the telemeter, the inventor has marked the circle with grade values, which greatly vary in different parts of the instrument. For telemetric purposes greater precision could be attained by graduating the circle in the ordinary way and carrying a table of grades with the corresponding circle readings: to these the index might be set with great accuracy by means of a vernier in the usual way.

The grade limit is double the angle of inclination between the axes, and in general it is obvious that this inclination is a fundamental constant governing the operations of the instrument. The angle of inclination of the telescopic sight-line at any part of the arc may be thus found—



In the figure suppose the sight-line to be turned from the initial position through the arc θ , measured on the inclined graduated circle $P P'$, so as to occupy the position $O P'$ (O is the intersection of the inclined axis and the sight-line, and O' the centre of the graduated circle). By projecting P' on $O' P$, and observing that if p'' be vertically above P' and in the horizontal plane through $O P$, $p p' = p'' P'$, it is evident that the angle $p'' O P'$ or γ is given by the equation

$$\sin. \gamma = k \text{ vers. } \theta \dots (2)$$

in which, if we put ι for the angle of inclination between the axes,

$$k = \frac{1}{2} \sin. 2 \iota \dots (3)$$

The equation (2) may also be written

$$\text{vers. } \theta = \frac{1}{k \sqrt{(g^2 + 1)}} \dots (4)$$

this last being required for computing the graduation reading corresponding to required grades. Thus with its aid we can select

pairs of readings which will make the telemetric factor m simple, one series of factors or grades being assumed and the other derived from the formula.

$$g' = \frac{m g}{m \pm g} \dots (5)$$

Occasionally horizontal angles may be measured by means of the inclined graduated circle, but the reduction is not convenient. By projecting O' on OP (the point o') and dividing $pp'' = P'p'$ by $po' + o'O$ the tangent of the horizontal value θ' of the inclined arc is given, thus:—

$$\begin{aligned} \tan. \theta' &= \frac{\sin. \theta}{\cos. \theta \cos. i + \sin. i \tan. i} \\ &= \tan. \theta \sec. i (1 - \tan.^2 i \sec. \theta + \tan.^4 i \sec.^2 \theta - \dots) \dots (6) \end{aligned}$$

The compass needle must generally be employed in determining bearings.

The adjustments of the instruments should be as follows:—

1. Collimation of the sight-line of the telescope by rotation in the containing collars; 2. Setting the axis of the bubble-tube or the telescope parallel to the collimated sight-line; 3. Adjusting the vernier or pointer so that when set at zero the sight-line shall be in the plane of the two axes. These are the permanent adjustments. The only temporary adjustment is the making of the outer axis vertical, which is required each time the instrument is set up, and is performed in the usual manner. Of these adjustments the one requiring special development is 3.

In deriving the relation between the grade angle and the circle reading the condition of adjustment was assumed; as it is now otherwise we must write $\theta + a$ for θ , and also add a constant, c , in (2). The problem will then be to find a , and readjust so as to make it 0 and to eliminate c . Then $\theta + a$ will be equal to θ , and the required condition is satisfied.

The procedure will be as follows:—Set a staff vertically at a convenient distance so that in the whole revolution of the inner relatively to the outer axis the collimated point of the diaphragm wires will intersect the staff. Mark or note the intersection on the staff at multiples of β degrees from 0° to $360^\circ - \beta$ (β being a multiple of 360°), and in each instance measure the sloping distance—which will, of course, vary—between the intersection of the inclined axis and the sight-line (O). Finally determine the point on the staff “on the the same level” as this point, O . Then the distance on the staff of each point from this last, divided by its slope distance,* will be the sine of the corresponding grade angle. Thus we have to express (2) in the more general form—

$$\sin. \gamma_m = k \text{ vers. } (\theta_m + a) + c \dots (7)$$

in which the left hand member is the sine of any grade angle, and

* This must not be derived from the horizontal distance to the staff because in revolving the axis the point O slightly varies its distance.

will be to hand in the form h_m/l_m , h being the measure on the vertical staff and l the sloping distance. If each of these quantities be multiplied by the sine of its corresponding circle reading θ_m , and similarly by the cosine, then the sum of the former (the sine products) divided by that of the latter (the cosine products) with its sign changed will be—

$$\frac{\sum_o^n \left(\frac{h}{l} \sin. \theta \right)}{- \sum_o^n \left(\frac{h}{l} \cos. \theta \right)} = \frac{\frac{1}{2} n k \sin. a}{\frac{1}{2} n k \cos. a} = \tan. a \dots (8)$$

in which n is $360^\circ/\beta$; when a has been found, k may be derived from either the numerator or denominator of the middle member in (8), these being the exact (unreduced) equivalents of the terms in the left hand member of the equation: $k + c$ is $1/n$ of the sum of h/l . The adjustment is made by setting the pointer at the reading $-a$, and, while keeping the axis in the same relative position, adjusting the pointer to zero.

In discussing the telemetric possibilities of the instrument there are two sources of error requiring attention, viz., inaccuracy in determining the constant k , or the angle ι on which it depends, and error of graduation. If k be carefully determined by readings at every 45° the error in the angle ι will probably not be greater than $10''$, and if the graduated circle be 5in. or 6in. in diameter, and be read by the verniers, $30''$ may be accepted as the probable limit of reading and graduation error. By differentiation we have from (2), (3) and (4) for a small error in the assumed value of the inclination angle the resulting error of grade, viz.—

$$\frac{dg}{g} = - d\iota \ 2 \cot. 2 \iota \left(1 + \frac{1}{g^2} \right) \dots (9)$$

from which we observe that, with $d\iota$ constant, the ratio dg/g is sensibly constant for any given instrument, and that in different instruments it is greatest for that with the least axial inclination.

For an instrument capable of measuring a grade of 1 in $2\frac{1}{2}$, or $21^\circ 48'$, the value of the ratio is—

$$-0.0002424 \left(1 + \frac{1}{g^2} \right)$$

Since, as we have noticed, this ratio is sensibly constant, the factor $gg'/(g \sim g')$ or m , in (1) must be multiplied by $1 \pm dg/g$ to give the true distance b , so that the effect of a $10''$ error in the assumed instrument will not be more than .00024, or say 1 in 4000. It is obvious that—

$$\frac{dg}{g} = - \frac{d\iota}{\iota} \dots (10)$$

is sufficiently exact for comparisons of this character.

It is a question, however, whether after wear the axis will not fit loosely, so that a considerable uncertainty in the angle of incli-

nation may be expected. Probably 1 in 2000 would be as much as one ought to expect after wear in the supposed instrument.

With regard to error of graduation or of reading, we find the ratio of the grade error to the grade to be

$$\frac{dg}{g} = -d\theta \cot. \frac{\theta}{2} \left(1 + \frac{1}{g^2}\right) \dots (11)$$

consequently with $d\theta$ constant, the ratio varies sensibly as the cotangent of half the angle read. This cotangent expressed in terms of the grade is

$$\cot. \frac{\theta}{2} = \sqrt{2k\sqrt{g^2+1}-1} \dots (12)$$

By differentiating the factor in (1) we obtain the ratio

$$\frac{dm}{m} = \left(1 \mp \frac{dg}{g} \cdot \frac{m}{g}\right) = \left(1 \pm \frac{dg'}{g'} \cdot \frac{m}{g'}\right) \dots (13)$$

and from these three we may compute the distance error arising purely from misreading or bad graduation. If the grade be the argument and is small, *i.e.*, expressed by a large number,

$$\frac{dm}{m} = -\frac{m}{g} \frac{d\theta}{g} \sqrt{2kg-1} \text{ approximately } \dots (14)$$

may be found a useful formula.

With the assumed instrument, in which 2ϵ is about $21^\circ 48'$, and maximum grade 1 in $2\frac{1}{2}$, we find, taking m as 100, the following values for the error, *viz.* :—

Angle	30°	60°	90°	120°	150°
Grade	40.18	10.72	5.29	3.45	2.71
Error dm/m . .	.0013	.0024	.0028	.0026	.0016

The maximum error is therefore .28 in 100, or say 1 in 350. Error resulting from the imperfect measurement of the angle in (7) will be insensible.

Probably the most convenient instrument for rough country would be one graded up to 1 in 5. This would be telemetrically a little more accurate than the instrument assumed in the discussion, and with a good telescope ought readily to measure to an average precision of 1 in 500.

The instrument will fulfil all the functions of an ordinary accurate level, and is, in addition, serviceable as a telemeter, a grade definer, and a rough level, the heights being found by means of the distances, telemetrically determined, and the grades. Its weight is but slightly greater than a level, as also its cost. In some form, therefore, it is probable it will be a permanent addition to the instruments of the surveyor and civil engineer.

Section I.

SANITARY SCIENCE AND HYGIENE.

1.—HOSPITAL CONSTRUCTION.

By C. E. OWEN SMYTH, Superintendent of Public Buildings, Adelaide.

PLATES XVIII.A AND XVIII.B.

In return for the honor done me in being asked to read a paper on hospital construction before this intellectual gathering I shall try to give, in as concise a form as possible, first, my own ideas as to the constitution of a first-class Australian hospital, and, secondly, a modification of the same where sufficient funds are not available to build a first-class institution.

I will, with your permission, glance for a few moments at the history of hospital construction. I believe it to be correct to say that there was an institution in Ireland 300 years B.C., founded by the Princess Macha for nursing the sick, and those wounded in battle. In the same century the great Gujeratee king Asoka built several hospitals in India. Later on at Cæsarea was built a great hospital and leper house. Alexandria had its hospital. Rome had a hospital in 380 A.D., founded by Fabriola, a pious Roman lady. The Emperor Justinian built the Hospital of St. John at Jerusalem. This hospital afterwards came under the control of the Knights Hospitallers, afterwards the Knights of Malta. The original order is now represented, I think, by the Christian Masonic Order of Knights Templars. The ancient Mexicans had hospitals and skilled surgeons. Again, in Spain there was the hospital founded by the Moors in Cordova in the eighth or ninth century. The Hotel Dieu of Paris, known as the Hospital of St. Christopher, was founded later on. In England, St. Thomas's and St. Bartholomew's were established in the sixteenth century, though the monasteries from early periods acted as outdoor dispensaries, and in very many instances had special rooms or wards set apart for the treatment of the sick; in fact the practice of the art of healing and surgery was principally in the hands of the monks in England and the Christian countries, and of the Jews in Spain. The eighteenth century saw the establishment of the present system of hospitals in England, under the direction of laymen, York, in 1710, being the first of a number which shortly followed.

I will now briefly sketch my conception of the requirements of a first-class Australian hospital. First, and of the utmost importance, a good high breezy site, if possible on a limestone plateau, with open surroundings and in a salubrious district; second, carefully-studied construction based on hygiene. Many have supposed that

architectural considerations should be allowed to predominate in the construction, but the true basis of hospital construction should combine the science of hygiene with the results of the experience of the best surgeons and medical practitioners—in short, such construction as will advantage the life and health of man rather than satisfy æsthetic tastes; and while the constructor should not be unmindful of the latter he must absolutely pay primarily the strictest attention to the proven results of medical experience, using his knowledge of construction to achieve the requirements demanded by the most advanced healing sciences, and always aiming to, as far as possible, deprive the causes which vitiate the air of a hospital of the power to create mischief, and only by striving to guarantee the essentials to good health can he hope to gain success as a constructor. Were money no object, and were I consulted as to the best method of designing a hospital, I would recommend a series of small one-story isolated pavilion wards grouped round a large central administrative block and equidistant from a main operating theatre, with special wards attached; each isolated pavilion ward to contain, say, from twelve to sixteen beds, with two small single bed separation wards, small ward operating room, nurses' room, ward store room, convalescents' day room, bath rooms with hot and cold water, separated patients' w.c. with fæcal trough and fæcal cupboard, nurses' w.c., and the whole surrounded with broad verandahs connected direct on each side with the wards, so that patients' beds could be wheeled right outside into the fresh air.

The administrative block should have in near proximity the kitchens, laundry, servants' house with housekeeper in charge, nurses' house with superintendent of nurses in charge, and in the rear the mortuary house, desiccating house, and steam disinfecting house; wards to be grouped separately for medical and surgical cases. Contagious diseases, and noisy cases or *delirium tremens* house should be set well apart; while for epidemics there could be temporary buildings in the extreme rear for use when required, each isolated ward to have a broad zone of aeration, and to be connected by tramline with the central operating theatre and the main administrative block. The small tramlines would carry the patients in an enclosed litter to the operating theatre, and food, coals, and materials generally for distribution round the wards. All walls should be of brick, and hollow, allowing free ventilation from ground line to underside of roof between walls, the sun-heated air being carried off thence by dormers; walls, including hollow, should be at least 20½ in. thick. Internally all walls of wards and theatre should be sheathed in glazed tiles; ceilings of panelled wood, painted and highly varnished, and covered on top with a heavy coating of seaweed; floors of Minton tiles, covered in winter with pieces of soft felting, frequently changed and disinfected; ventilation, &c., as will be hereafter described. Such wards as

described, with proper inlet and exhaust natural ventilation—2,000 cub. ft. of air per bed, 16 super. ft. of light per bed—perfect sanitary appliances, good nursing, and the professional care of a hospital staff, should be almost perfect.

The operating theatre block should contain waiting-room and instrument fitter's shop combined, anæsthetic-room leading into theatre, and a corresponding room on the other side for surgeons; and, connected by a corridor with the theatre, two four to six bed wards and two single bed wards with nurses' room between, as per plan which I exhibit (see Plate XVIII.B). In the operating theatre I consider it absolutely essential to have a zone of warm air surrounding the table in winter time; this can be provided with aid of gas-heated coil. I strongly recommend the cleverly-designed table used in our theatre to be inspected by visiting surgeons; the designer is Mr. Woods, the hospital instrument fitter.

The kitchen block should contain large kitchen proper, with roasters, cupboards, tables, &c., steam cooking kitchen, scullery and main boiler-house, from which all the steam required in the institution can be supplied, viz., cooking steam, steam for hot water generators for distribution by gravitation from special tower in administrative block to all wards and buildings, steam for washing machines in laundry, and for drying room, also for the superheated steam disinfecting machine; and here I may say I know of nothing better for hospitals than the Washington Lyon machine. The superheated steam process of disinfecting has, owing to its excellent results, completely superseded the use of the dry hot air process. To go back for a moment to the kitchen, large well-ventilated cellarage is an absolute necessity, the whole including ventilation shafts rendered fly-proof. The kitchen should also, by use of wire doors, wire window screens, and ventilation openings, be fly proof. By using jacketed copper boilers and ordinary direct steam copper boilers the cooking of potatoes, vegetables, boiled meats, soups, &c., for large numbers is rendered comparatively easy. Colonial-made ranges can do the rest in roasting, baking puddings, &c. Kitchens should have ironed Seyssel asphalte floors with central drainage for frequent hosing. Walls can be unplastered with struck flush joints for whitewashing, which should be done periodically. Laundry block should have walls and floor as for kitchen, and contain steeping and disinfectant tank and steam boiling troughs, and automatic washing machines, drying room for bad weather worked by steam pipes, or, if too great a strain on the supply of steam by furnace, with circulating smoke flue; mangling and ironing room should be attached. Separate troughs should be provided for the clothes of staff, nurses, servants, &c.

The mortuary house should contain a large *post mortem* room with smooth Seyssel asphalte floor, plentiful supply of hot and cold water, extra light and semi-open roofs, carefully graded

drainage of floor, with cemented or tiled walls; also inspection room where bodies are confined and await the undertaker. The whole of the mortuary should be absolutely fly-proof, and allow a free circulation of air.

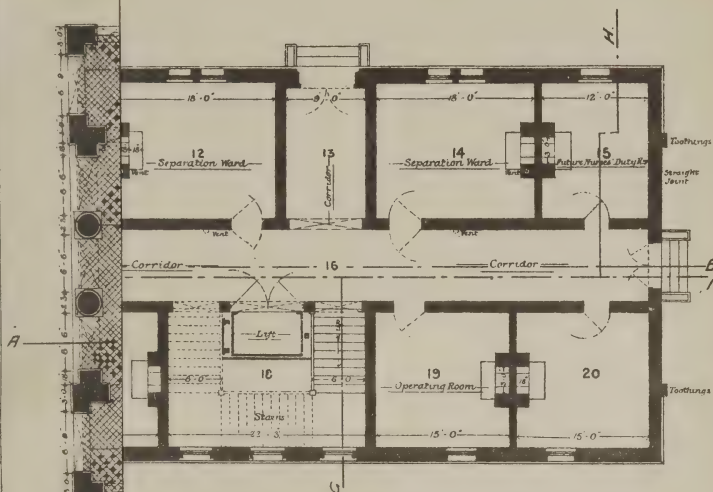
I should not forget to add that a special fire service is an absolute essential in designing a large hospital, also swimming baths, tennis courts, dancing room, &c.

As "The money no object" basis of the ideal hospital just described is not attainable at present in Australia, with bank reconstruction and curtailed estimates, I shall proceed to describe what I trust may be termed a good serviceable hospital, taking, in terms of the request made by the Committee of Section I., the southern portion of the east wing of the new Adelaide pavilion hospital as an exemplification of a portion of this class of institution.

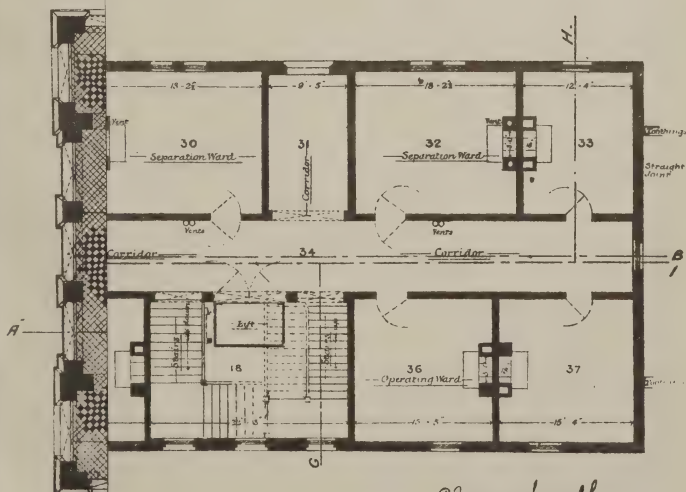
The Adelaide Hospital (see Plates XVIII.A and XVIII.B), being a clinical institution, must of necessity be in close proximity to the school of medicine in the city; consequently the area of site is limited, in fact too much so, and while a good zone of aeration is obtainable in the north-east and west and to a certain extent on the south within the area available for the future hospital, the space is too limited for such results as a conscientious constructor would desire to attain.

A little extra money expended to insure dependable foundations in a hospital, as in other buildings, is always true economy. Should the "ground" be bad or unequal, a false bottom or cushion of fine sugar sand from 12in. to 18in. deep, according to circumstances, has proved itself a perfect cure, and by the introduction of two rows of railway irons into the centre of the concrete a further bond of security is established. Either clinker bricks or hard flat stones of extra large size can be used for foundations walls between concrete and floor line, and to prevent a possibility of damp or magnesia rising two courses of damp proofing are desirable, either ordinary gas tar and sand or Seyssel asphalte being used where obtainable of good quality.

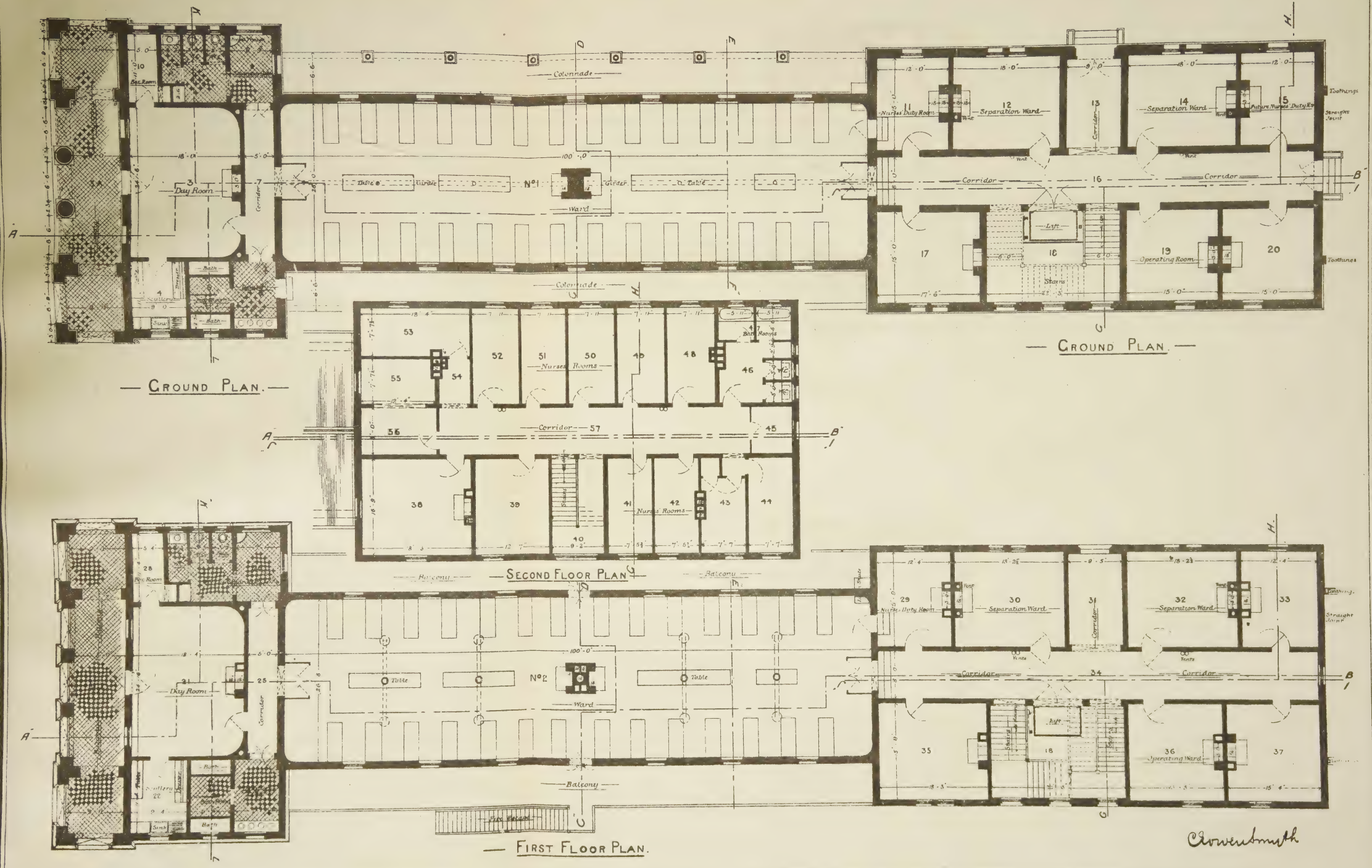
I prefer bricks for construction of superstructure. Brickwork is cheaper than stone and makes sounder work. Hollow walls are very desirable in this hot continent, but they have their disadvantages in a two or three storied building as lacking in stability, though this can be overcome by increasing the thickness and consequently the cost. The operating theatre block has hollow walls, being a single-storied building. As mentioned before, a Minton tiled floor is suggested as being the best from a hygienic point of view; this, however, means money, and the next best floor is hardwood. Personally I prefer jarrah to any other wood, but again cost interferes, as to ensure a sound close-jointed floor the timber ought to be specially selected, milled and seasoned for at least three years before use, and even then probably 25 per cent. of the



— GROUND PLAN —

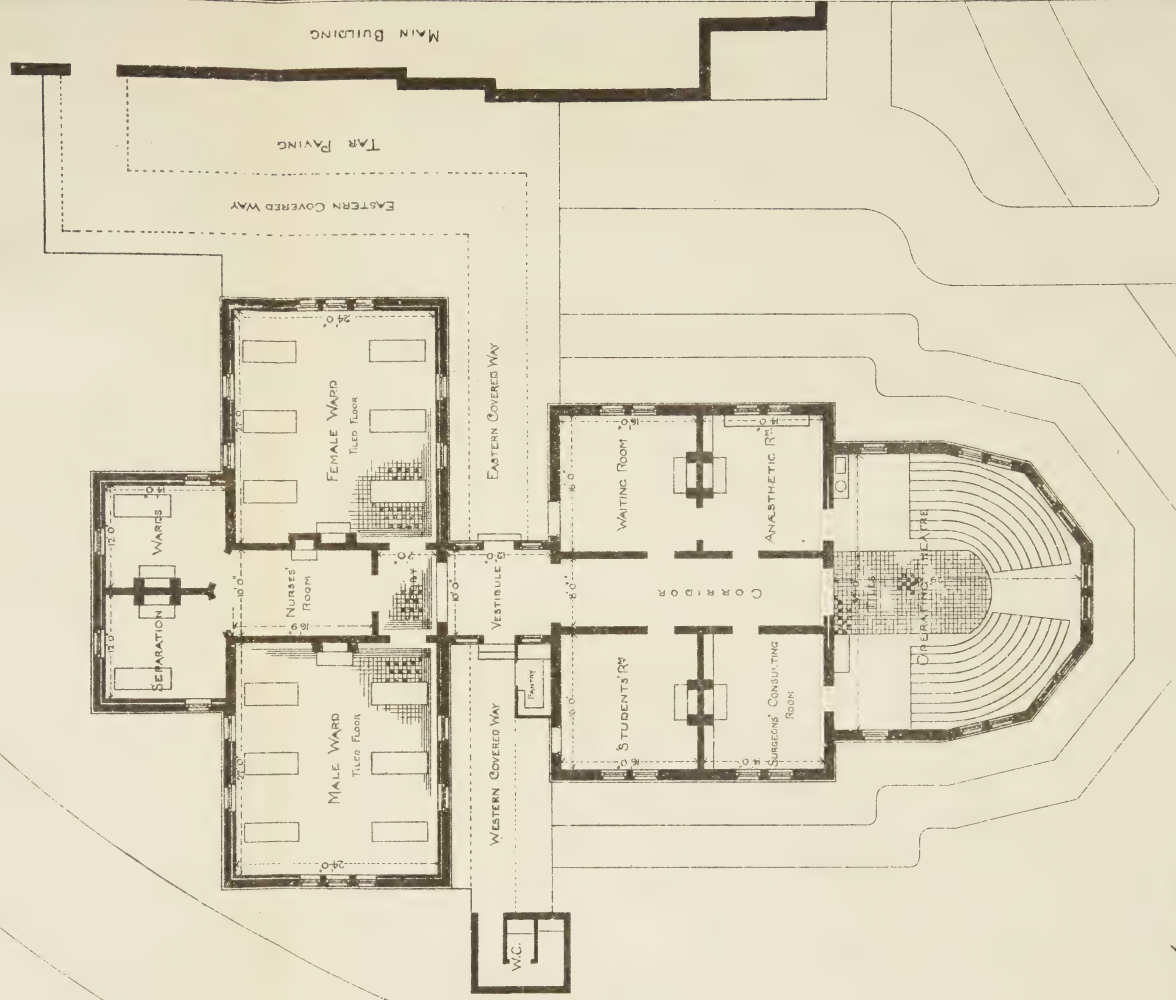


Crowensmith



Crowenbush

OPERATING THEATRE BLOCK & WARDS,
ADELAIDE HOSPITAL.



Chas. S. Smith

boards may have to be rejected before securing a first-class floor. But when a good jarrah floor is obtained but little is left to be desired. The proper treatment for such a floor after being cleaned up and papered is a thorough saturation with raw linseed oil, then varnish, and finally hot beeswax and turpentine, rubbed up to a smooth shining surface. After jarrah our choice of available timber is limited to pitch pine or New Zealand kauri; either gives a splendid floor, but care must be exercised with each. The former should be high colored and have two or three years' seasoning; the latter should be light colored in contradistinction to red, and used bone dry, care being taken to exclude all damp air from underside for a season. Both floors should be waxed.

A room 100ft. long x 26ft. wide and 18ft. high, giving nearly 1,800 cub. ft. of air each to twenty-six beds, is an economic ward. The corners should be rounded to do away with internal angles, and so prevent dead air. As little woodwork as possible should be used, a coarse Keene's cement for architraves, window lining, and skirting being preferable to wood, and as little moulding as possible. When ready the walls should have five coats of paint and two coats of the very best elastic varnish. The ceiling can be of plaster, wood, or 28-gauge small-fluted corrugated galvanized iron. The latter makes a splendid ceiling, and leaves little to be desired, and is considered an improvement on lath and plaster, not being subject to crack or fall down. In any case, whether plaster, wood, or iron be used, the ceiling must be painted and varnished, and in the case of a two-storied building sound deadening must be filled in above ceiling and under the floor of the ward above. A central fireplace is considered an improvement on the old system of fireplaces in the walls, and the main shaft can be used for decorative purposes to brighten the ward.

In Australia natural ventilation has, I believe, been found to answer all purposes in hospital construction when judiciously applied. Fresh air should be introduced through the external walls, delivering under each bed, and again at, say, 7ft. 6in. or 8ft. above floor level, with a special terminal to prevent the cold air falling directly on the patient below; while by a system of extracting pipes from ceiling and pipes carried up in centre of chimney shafts, aided by the fires in winter and the difference of temperature between internal and external atmosphere in summer, helped again by the wind acting on the specially-constructed terminal cowls on roof, the experience of several years has proved that hospital smells can be conquered, more especially if the attendants will judiciously use the fanlights placed over each window as an additional aid at night and the windows themselves in the day time. Free currents of air should also pass from end to end of the whole block, and from side to side. Wards should have large arched openings with screens within, uncovered, thus allowing free passage of air without direct draught; each large ward should be provided with a dirty linen shoot delivering from

ward to outer air direct, and thence into laundry truck *en route* to steeping and disinfecting trough.

In connection with such a ward as described should be a day room for convalescents, the day room combining the useful with the helpful, as it allows patients sufficiently recovered to leave their beds to sit there and have their meals; it also helps the wards by removing so many out for a certain time each day, giving more air to those remaining. In conjunction with day room should be separated w.c.'s., specially designed so as to be cut off by a fresh air space from the building proper; the lavatory and baths with hot and cold water. Store room and ward scullery should be all connected with deep drainage, and almost perfect sanitary appliances. (I may say our South Australian system is as nearly perfect as obtains in any part of the world at present; an inspection will illustrate better than words). A well-flushed glazed faecal trough and a cupboard for excreta requiring inspection by medical officers should be contained in the closet arrangements. Access direct either from wards or day room should obtain to ambulatory verandahs and balconies, &c. These should be on all sides, to allow patients to have the benefit of sun or shade, according to the season of the year or time of the day.

On the opposite end of large ward to day room, &c., should be the room of the sister in charge or head nurse, with glass door, giving full view over ward; also a small ward, operating and casualty room, store room, and a separation ward of three beds for special cases; this room should have double doors, and be as well ventilated as main ward. Repeat the ground floor plan on first floor, with balconies, &c., and the accommodation is at once doubled. External fire escape stairs should be provided from balcony. In our hospital we have provided an Otis hydraulic lift for patients, and to send up dinners, &c., to first floor. A staircase travels round the elevator case for ordinary traffic and a special water service is provided for use of the lift. As space is limited with us, a second floor or third story has been built on central portion of wing for the ward nurses, &c., accommodation for sixteen being provided, the floor being 39ft. above ground. Nurses have bath rooms, with hot and cold water, and w.c.'s, &c., on their flat, also connection with a large platform on roof, overlooking the city, for taking the air on fine nights. Ward furniture requires a few words. Bedsteads should be very strong, with woven wire mattresses carrying the horsehair mattress; the latter need not be more than 25lbs. weight. These bedsteads are made in the colony. Each bed should have bracket on wall at head for medicines, name of patient, and his ailment, &c. A small table on solid pedestal is provided for each bed. Electric lighting is the proper thing for hospitals, as the gas consumes so much oxygen. There should also be electric call bells. One word and I close: No constructor should ever forget the claims of the nurses to generous treatment in the shape of comfortable accommodation.

2.—CHARACTER OF THE SOUTH AUSTRALIAN WATER SUPPLY.

By G. A. GOYDER, F.C.S.

Having analysed a large number of samples taken from the principal sources of the water supply of this colony from 1890 to the present time, principally for the Engineer-in-Chief's Department, it appeared to me desirable to give some account of these waters chiefly from a chemical point of view. The waters may be divided into three classes, all being surface waters, as most of our deep waters are too saline or in too limited quantity for a large supply—soft waters from the slates and clay lands; hard waters from the limestone formations; saline waters. The number of soft waters met with here is very limited, the purest organically being that from the Waterfall Gully, which is utilised, as far as possible, to supply Burnside and Kensington; an analysis of this water is given in Table 1, under Kensington, and it will be seen that the water is fresh, moderately soft, and organically pure. This soft water in passing through the pipes takes up a little coloring matter from the protecting composition with which they are coated the more so the softer and less saline the water is. This sometimes leads to an idea that the water is impure, but as the coloring matter is innocuous and the quantity present exceedingly small, this idea is erroneous. As an example of this the Kensington water of July, 1890, may be quoted. In the Burnside South reservoir this water had a color equal to 0.79 (see appendix); after passing through the pipes the sample drawn at Kensington had a color equal to 2.43, about three times as deep, the organic impurity in the water being less than in the reservoir. Hard waters, after passing through similar pipes, do not take up a trace of color, and where otherwise pure appear of a normal pale blue when seen through a long tube. I do not know of any other case in which we have a soft water organically pure that is utilised, although there may be others, which, being mixed with an excess of hard water, are not recognisable under this heading.

There are a number of soft waters obtained from a catchment area of clay land, the Nelshaby and Kapunda reservoirs being supplied with water of this description. Generally these waters are so contaminated with organic matter, chiefly vegetable, that they hold a considerable quantity of matter in suspension, and are both turbid and organically impure, and capable of supporting a large number of infusoria and other forms of life which make them undesirable for drinking purposes if not actually dangerous. The comparative degree of organic impurity of the Nelshaby water varied during 1890-1 from 2.99 to 6.32. Since May, 1891, however, the water in the reservoir has been supplemented from the Beetaloo reservoir, and the improvement of the water has been proportionate to this supplementary supply.

The Kapunda water is the least saline of all our waters, and also very soft, but holds such an enormous quantity of matter in suspension that it is hardly, if at all, used for drinking purposes; its principal use being for locomotive engines, for which it is particularly adapted, especially in connection with other waters of a hard saline character.

Among moderately hard waters the purest is that in the Blue Lake at Mount Gambier used for supplying the town. The source of this water is not accurately known, but its great organic purity will be seen from the analysis in Table 1. The water in this lake is subject to periodical disturbances, during which the water loses its wonderful clearness, but the matter brought into suspension quickly subsides, leaving the water almost purer than before. Sufficient data has not been obtained to explain this phenomenon. I am inclined to think it may be caused by the inrush of a volume of gas near the bottom, which, stirring up the sediment, causes the water to lose its transparency for a time. The Beetaloo water is another example of a hard water, it being, for fresh waters, probably the hardest utilised here for a large supply. The organic purity of this water varies very greatly according to the season. Sometimes the Beetaloo water supply is purer than that of Hope Valley; at others the quantity of flood water taken in makes it much worse for a long time. The analysis of Beetaloo flood water in Table 1 shows how bad this water may be during a very heavy flood. Unfortunately the uncertainty of the rainfall in this colony makes it necessary in some cases to let water into the reservoirs while the streams are still turbid. Further on I have endeavored to point out a means by which our flood waters could be utilised to a large extent and a pure clear supply secured. A great many waters which might otherwise be utilised are too saline.

In Table 1 analyses of the Port Augusta, Gawler, and Bundaleer Creek waters are given. The Port Augusta water approaches the limit of salinity permissible, but is at the same time generally of considerable organic purity. The Gawler water is certainly more saline than is desirable, but is apparently used without any ill effects. The water from Bundaleer Creek is too saline for the supply of a large town. In some cases where the usual flow is too saline for a potable water the flood waters could be utilised, but would require purification.

The natural purification of the waters in this colony is very quick under favorable circumstances, and the Gawler supply appears a good example of this quick purification. The nitrogen as nitrates in this water renders it of a very suspicious character, and the analyses are watched with some degree of anxiety. The Magill water also contains so much nitrogen as nitrates as to cause suspicion regarding previous contamination, although otherwise it is a very pure water. The nitrogen as nitrates in other waters sometimes varies very much; thus in the water from the weir at the Torrens Gorge it rose from 0.026 in February, 1893, to 0.099

in August. This may probably be ascribed to the drainage from the manured land. The best example of quick natural purification that has come under my notice, however, is given by the sewage at Islington. Of the two analyses of this water in Table 1 one is of the influent sewage after passing the strainer, the other of the water flowing away in the creek below the farm; but for the salinity and high nitrates of the latter it would be difficult to recognise it as a sewage water. The figures given for the Islington waters can only be taken as very approximate, as a long series of analyses would be required to obtain the mean composition of the influent and effluent, but the above are quite sufficient to show that the land is most suitable in this respect for a sewage farm. It is most desirable that frequent analyses be made of the intake and effluent of the sewage waters, especially to learn whether the salinity of the land is being increased by the continued irrigation, the water running from the farm being at least five times as saline as the water of the city supply.

In Table 2 monthly analyses of the Onkaparinga water from samples taken at Clarendon are given to illustrate the variation of organic purity and salinity with the seasons. A similar variation occurs with most of our waters. The waters are generally of greatest organic purity just before the heavy rains of winter set in; they are then also most saline and hard. Immediately after the first heavy rains they are organically most impure and least saline, and it is owing to this last quality and the general scarcity of a suitable supply that the purification of turbid water would be of such immense advantage here. The Beetaloo flood water is, for instance, of about one-fourth the salinity of the ordinary flow, and the Onkaparinga the same, and such waters as the Bundaleer Creek, and even the Rocky River, at Huddleston, might not be too saline for use if collected during a heavy flood. After a heavy rain this year the Beetaloo reservoir was filled with water containing only ten parts of saline matter per 100,000, the average quantity for the three previous years being from fifty or sixty parts.

On looking over a long series of analyses of the same water collected from reservoir and service pipe, it becomes evident that the latter is decidedly organically purer than the former, the passage through the pipes appearing to have a purifying action. This may be due in part to a subsidence of some of the organic matter in the mains, this being afterwards removed by flushing; but, as it occurs with the clearest waters as well as with the most turbid, it is probably partly due to the iron reacting on the aerated water; examples of this greater purity of the service water are given in Table 5, each analysis given being the average of twenty-four analyses, extending over two years.

On examining tabulated analyses of our principal potable waters it appears that there are only three of them which can be almost continuously classed as organically pure; these are the Blue Lake at Mount Gambier, the Port Augusta, and the Gawler supplies.

Unfortunately the two latter are decidedly saline, and the last is, as before mentioned, suspicious from the quantity of nitrates it contains. Other waters, such as the Magill, Kensington, and Beetaloo, are sometimes pure and sometimes impure, while others are invariably below the standard of organic purity. This is not surprising when we consider that all our supplies are derived from surface waters, and that much of the water run into the reservoirs is decidedly turbid, not from carelessness, but because it is under existing conditions a case of turbid water or none. It becomes increasingly necessary therefore to consider what means can be applied to render our potable waters of greater organic purity.

PURIFICATION.

1. By sulphate of alumina.
2. By lime (Clarke's process).
3. By filtration.
4. By agitation with iron and aeration (Anderson's process).

1. *By Sulphate of Alumina.*—This process is suitable for treating soft waters which cannot be purified by Clarke's process. In Table 5 the result of this process on a small scale with the Kapunda water is given. Commercial sulphate of alumina (hydrous) was added to the water at the rate of 1lb. per 1,000 gallons, the water agitated, allowed to settle forty hours, and the clear water syphoned off and analysed. The improvement in the water is most marked. The objection to this process is that should an excess of sulphate be added it renders the water slightly acid, but with care the effluent is quite neutral. This process has been found to answer equally well with other waters of a similar character.

2. *By Lime (Clarke's Process).*—Table 5 shows the improvements effected on a sample of Hope Valley reservoir water. The improvement from an organic point of view is not nearly as marked as by the alumina or the Anderson process, and few of our waters are sufficiently hard for this process to be of striking utility.

3. *By Filtration.*—I have not had an opportunity of testing an efficient sand filter on our waters. In Table 4 an example is given of the organic improvement effected by one of G. Cheavin's filters on the Adelaide service water of September, 1891. The effluent from this filter was of very great purity, and the change effected in the water can, I think, only be ascribed to the oxidation of the organic matter by micro-organisms present in the filter. The efficient filtration of large quantities of water through sand or other medium presents considerable difficulty and continued watchfulness and attention as to the rate of flow, the quality of effluent, and the state of the filter bed. A filter bed has three stages: the preparatory, during which much organic matter passes through with the water, which should not be allowed to pass into the service pipes; gradually the surface of the filtering medium becomes coated with a fine covering of a gelatinous-like nature, and the filter passes into the second or efficient state, when the water becomes fit for use.

The third state is that either the water passes too slowly or the bed becomes so foul as to be dangerous. It then becomes necessary to prepare a new bed either by thoroughly cleansing the old material or providing fresh. The great objection to filter beds appears to be that there is always a chance of danger from the concentration of germs in them, and from the possibility of the films of organic matter affording a suitable material for the growth of pathogenic organisms in large quantities, some of which may be passed into the service by some irregularity of action. Domestic filters, unless frequently cleansed and intelligently used, are even more liable to the same danger. This danger arises from the fact that a few germs of a disease introduced into the system are generally easily overcome without inconvenience, but if introduced in greater numbers they produce their specific illness.

4. *Anderson's Process*.—This process consists in passing the water through a revolving cylinder containing a quantity of small pieces of iron; air is in some cases pumped through the water at the same time. After leaving the cylinder, in which it remains on an average three and a half minutes, it is again aerated if necessary to peroxidise the iron which has been dissolved. The oxidised iron precipitates and subsides quickly, carrying down with it much of the organic matter present, and the water may be readily filtered or allowed to clarify by subsidence for a day or two.

From the analyses in Table 5 it will be seen that the Adelaide service water treated by this process is changed from an impure water to one of a high degree of organic purity, leaving nothing to be desired either chemically or biologically. Tests by this process have been made with much more impure waters, such as those of Kapunda and Nelshaby, and it was found that a clear and colorless effluent could be obtained even with these waters if aeration during the agitation with iron were employed. As an example of the especial adaptability of this process for this colony I will point out how it might be advantageously used for the large reservoir at Happy Valley. This reservoir will have a capacity of about 3,000 million gallons, and during the four or five winter months about thirty million gallons a day can be taken from the Onkaparinga River. To treat this quantity the water would be passed through a battery of revolving cylinders having a total capacity of 80,000 gallons, in which it would remain on an average three and a half minutes; after leaving the cylinder the dissolved iron would be peroxidised by forcing air through the water, which would then be led to a settling reservoir having a capacity of thirty million gallons. Two such settling reservoirs would be required, one being filled while the clear water was running from the other into the large reservoir. The reservoir would thus be filled in about three months. In Table 2 it will be seen that the Onkaparinga water during these months is about half as saline and less than half as hard as the average Hope Valley reservoir water, but is much more impure. I have calculated from the literature on the Anderson

process that the Onkaparinga water could be purified at a cost of about one farthing per thousand gallons, including allowance for interest and depreciation on all machinery, &c., capable of treating thirty million gallons per diem. The cost of treatment would be less if the impure water were allowed to run into the reservoir and the water purified for use as required, as in this case machinery would be required for treating less than ten million gallons per day, but I strongly advocate the former method for the following reasons:—Practically no silt would enter the reservoir, and hence the cost of keeping it in order would be greatly reduced. The water in the reservoir would be so pure that there would be a minimum of life in it, whereas with impure waters the reservoirs teem with life in consequence of the abundance of food material. The water after treatment is in such a state that all suspended matter quickly subsides, and the water drawn off from a depth is quite sterile. (See page 13, B Notes.) Direct sunlight has been proved to be fatal to many species of bacteria, and the purified water would allow the light to penetrate to a much greater depth than the impure turbid water. By long standing after treatment the water undergoes considerable natural purification, and attains a more natural and healthy state for use than if used directly after treatment. It has been remarked that waters from a great depth and those which have been chemically treated are not so healthy as those from a moderate depth, or those which have had time to attain a natural character after treatment by standing exposed to the sun and air. I am unable at present to quote the authority for this statement. In addition to the above there would be a considerable saving of water whichever system was adopted in consequence of the smaller quantity required for flushing the mains. Lastly, the expense incurred in purifying the water seems to be very small for such an excellent result.

The continued use of impure waters, as the population and thence the chances of dangerous contamination increases, is certainly most undesirable. By adopting a system of purification as soon as and wherever practicable the general health of the community would certainly be improved, and it is possible that some epidemic diseases would be greatly diminished in frequency of occurrence, and perhaps others prevented from obtaining a footing here.

BACTERIOLOGICAL NOTES.

Dr. A. B. Griffiths, F.R.S.E., &c., in a paper on "A New Method for the Bacteriological Examination of Water" ("Chemical News," May, 1893, page 234), says:—"In addition to the above-mentioned conditions the number of microbes in any water depends upon the amount of organic matter present. A water rich in organic matter always contains a larger number of microbes (in a given volume) than a water almost free from such matter."

The above remark applies not only to microbes, but to many other forms of life, and doubtless the entrance of impure water

into our reservoirs, and especially of flood water, introduces much life and food for life with it. Bacteria, algæ, and infusoria abound, and the latter afford food for fishes, which in some reservoirs, into which turbid water has been introduced, multiply very fast. Many of them doubtless die in the reservoir and supply food for a fresh crop of bacteria, &c., while others, issuing from the service taps and blocking the meters, awake the public to the fact that our waters are not all that they should be. It is indeed notable that most of the complaints as to the impure state of our waters are made at a time when they are, as regards organic purity, at their best.

In Table 7 the results of a series of experiments on bacteria in the Adelaide service water are given. A number of Wynchester quarts of this water were drawn at the same time from the service pipe, the bottles having been thoroughly cleansed; of these one-third were untreated, one-third were purified by the Anderson process and the water decanted, the remainder treated by a modification of the Anderson process. To test the number of bacteria in the waters l.c.c., or less, of water was mixed with sterile nutrient gelatine and poured into a sterilised bottle, on the sides of which it was spread evenly, and allowed to solidify. The bottle was then placed in an incubator at about 22° C., and the number of colonies counted after two or three days. Blank experiments were made to prove that no growth occurred when sterile water was used. The number of bacteria is always given per cubic centimetre. The number of bacteria in the water was reduced from 320 per cubic centimetre in the original, when first drawn, to only 5 in the purified water, after standing two days, while in the untreated water the number had increased to 180,000 in the same time, this being the maximum number obtained in the untreated water, probably in consequence of the presence of infusoria in the water, which kept the bacteria from excessive development. The advisability of using freshly-drawn water for drinking purposes in preference to that which has been standing for some time is very evident from the above.

The number of bacteria in the purified waters rapidly increased until after standing seven days; they each contained about 700,000. Two days later a sample was very carefully taken at 9in. from the surface of the same bottle, and this, after cultivation and keeping for several weeks, did not develop a single colony. It would therefore appear that most, if not all, the bacteria that flourish in what would be classed as an originally pure water are aerobic and confined to the surface of the water. After the seventh day the number of bacteria at the surface in the purified water gradually decreased, and according to the last experiments is still decreasing, probably owing to most of the food material having been exhausted, as all infusoria must have been destroyed during the purification of the water. The number of species found in the water after two months was three, as compared

with five in the unpurified water. With the latter the gelatine was all liquefied in three or four days, while with the former liquefaction was not complete after as many weeks. (It is intended to continue these experiments.)

The comparatively small number of bacteria found in the mains of the different water supplies that have been tested by me (see Table 8), viz., from sixty-four to 266, appears very small if we remember that all are unfiltered surface waters; and, taking the numbers only into consideration, the waters would probably all be passed as healthy. The reason for this small number of bacteria is explained by the experiment in Table 7, already quoted, where from the sample taken as deep as possible not a single colony developed, while a sample taken from the surface contained about 500,000, and by the fact that the water is taken from the reservoirs by a valve about 16ft. from the surface. The number of species of bacteria which could be distinguished from the different aspects of the colonies when examined by a Coddington lens amounted in the Adelaide and Mitcham waters to twelve, and nearly all of these proved to be bacilli when examined under the microscope. This large number of species with the comparatively small number of bacteria renders these waters of a suspicious quality. It will be seen, on comparing Table 8 with Table 6, that the number of bacteria in the waters varies directly with the turbidity, and it would appear that to a great extent the majority of the species are attached to small particles of suspended matter. In order to correctly gauge the significance of finding twelve species of bacteria in 1c.c. of water, cultivated at 22° C. on nutrient gelatine after three days' growth with access of sterile air, we must remember—

1. That some species, mostly pathogenic, only develop at a temperature of about 37° C.
2. That others require weeks before the colonies have developed sufficiently to become visible to the naked eye.
3. Others again do not develop at all in the nutrient gelatine.
4. The purely anaerobic species develop only when air is excluded.
5. Some require the presence, others the absence, of light.
6. Colonies which appear alike macroscopically may belong to altogether different species.
7. The small quantity of water necessarily taken for each test.
8. The liquefaction of the gelatine frequently putting an end to further observation after two or three days.

So that where twelve species are found as above, there are probably many more kinds actually present, and the species which have not developed are more likely to be pathogenic ones.

I regret that the limited time and apparatus at my disposal have prevented my going more fully into the bacteriological study of our water supplies, but think at the same time that the few experiments I have been able to make fully confirm the results of the

chemical analyses, and further point to the desirability of purification, and to the possibility of the elimination of all bacteria from our waters as drawn from the service pipes. It is hardly necessary for me to point out that in many cases where bacteria do not produce any epidemic they may cause complications and render other diseases more dangerous, or they may in other cases, by producing small disorders of the system, pave the way for more serious illnesses.

I have to acknowledge the courtesy of Mr. Moncrieff, the Engineer-in-Chief, in supplying me with reports and samples of meter.

APPENDIX.

ON METHODS OF ANALYSIS USED.

"Total solids"—Includes all residue left after drying to constant weight in a large water bath at 100° C.

"Chlorine"—Determined volumetrically, using potassium chromate as indicator.

"Carbonic acid radicle, CO_3 "—By titrating a known volume of water with $\frac{1}{10}$ th normal hydrochloric acid, using cochineal as indicator and 0.060 as factor for CO_3 as bi-carbonates.

"Ammonia free"—Distilling and nesslerising.

"Ammonia albumenoid"—Distilling with alkaline permanganate and nesslerising.

"Oxygen absorbed in fifteen minutes," "Oxygen absorbed in four hours"—Tidy & Frankland's process.

"Nitrogen as nitrates"—By copper zinc couple with addition of a little sulphuric acid, pouring off after twelve hours, precipitating with caustic soda, allowing to settle, decanting and nesslerising, allowance being made for free ammonia and for ammonia in re-agents.

"Comparative degree organic impurity"—Calculated from the formula given by Mr. John Muter ("Analyst," June, 1883).

"Opacity"—1.0 indicates an opacity equal to that produced by one part of kaolin in 100,000 parts of water. The standard solution of kaolin is made by shaking powdered white kaolin with distilled water, allowing to stand twenty-four hours, and decanting off the unsettled portion, which is diluted to the required strength, 0.1 grain per litre being convenient for use. This and the color test are best made together on the same sample.

"Color"—10.00 indicates a color equal to 0.0001 ammonia (NH_3) in 100c.c. of water nesslerised; the tests being made with a solution of caramel in 50 per cent. alcohol, a known volume of which is equal to 0.0001 nesslerised ammonia in 100c.c. of water.

Although these tests for color and opacity are not of great scientific accuracy, they are of easy and cheap application, and are decidedly better than such terms as "slightly yellow," a "trace opaque," &c. Strongly colored or opaque waters should be quantitatively diluted before testing.

TABLE 1.
IN PARTS PER 100,000.

Source of Water.	Total Solids.	Solids in Suspension.	Chlorine.	Carbonic Acid, Rad. CO ₂ .	Free Ammonia.	Albumenoid.	Oxygen Absorbed in Fifteen Minutes.	Oxygen Absorbed in Four Hours.	Nitrogen as Nitrates.	Opacity.	Color.	Comparative Degree of Organic Impurity.
Kensington, May, 1890, soft pure water	21.40	—	9.51	3.72	0.0604	0.0008	0.0236	0.0476	0.0080	0.05	0.71	0.07
Nelshaby, December, 1890, soft impure	29.90	12.50	6.04	1.88	0.0114	0.0628	0.3392	0.5928	0.0440	2.00	7.30	4.37
Kapunda, August 1890, turbid ..	44.40	32.70	1.71	3.06	0.0016	0.0806	0.4604	0.8048	0.0760	18.00	15.00	5.94
Mount Gambier, May, 1890, hard pure	39.40	—	11.98	20.64	0.0003	0.0011	0.0036	0.0072	0.0130	nil	nil	0.02
Beetaloo, May, 1890, impure, hard Do. June, 1893, flood water ..	61.10	—	13.58	45.78	0.0086	0.0250	0.0964	0.1756	0.0090	0.20	0.20	1.66
Port Augusta, June, 1890, saline, pure	72.90	62.10	1.68	4.14	0.0026	0.0400	0.6272	1.4464	0.0178	24.00	9.00	6.23
Bundaleer Creek, May, 1892, too saline	77.40	—	23.31	40.80	0.0008	0.0008	0.0072	0.0168	0.0830	nil	nil	0.03
Onkaparinga, May, 1890, summer Do. August, 1890, flood ..	199.20	—	78.30	33.24	0.0058	0.0196	0.0664	0.1420	0.0585	2.40	1.60	0.37
Gawler, June, 1890, natural purification	76.50	—	24.95	33.24	0.0008	0.0140	0.1004	0.1768	0.0070	0.70	0.20	0.72
Islington, sewage entering farm.. Do. creek from farm	20.00	2.20	5.57	5.82	0.0052	0.0176	0.2628	0.4732	0.0420	1.00	1.43	2.33
	93.70	—	37.97	26.40	0.0006	0.0034	0.0168	0.0364	0.2806	nil	nil	0.08
	204.70	?	65.40	65.16	1.6360	1.4210	1.7052	3.5656	nil	P	P	82.72
	337.20	—	142.30	69.76	0.0016	0.0096	0.0284	0.0708	1.7290	0.20	0.04	0.20

TABLE 2.

SHOWING VARIATION OF WATER FROM MONTH TO MONTH DURING 1890.

Onkaparinga,	47-70	—	15-46	19-44	0-0020	0-0400	0-1730	0-3200	—	—	2-21
Do.	52-80	—	17-00	22-00	0-0020	0-0340	0-1550	0-2800	—	—	1-57
Do.	59-40	—	18-84	22-20	0-0080	0-0490	0-1790	0-2440	—	—	2-36
Do.	59-40	—	19-65	23-64	0-0034	0-0290	0-1420	0-2350	—	—	1-52
Do.	76-50	—	24-95	33-24	0-0008	0-0140	0-1004	0-1768	0-30	0-30	0-72
Do.	27-40	—	7-78	5-04	0-0032	0-0342	0-4280	0-7663	0-70	0-20	0-72
Do.	25-10	—	7-01	6-18	0-0024	0-0308	0-2736	0-4596	0-40	1-43	4-30
Do.	20-00	—	5-57	5-72	0-0052	0-0176	0-2628	0-4732	0-80	1-28	2-73
Do.	31-70	—	8-86	5-40	0-0054	0-0230	0-2800	0-5256	1-00	1-43	2-33
Do.	27-00	—	6-05	5-82	0-0054	0-0450	0-4068	0-6952	4-00	1-43	2-69
Do.	24-00	—	6-53	6-72	0-0042	0-0414	0-3576	0-5670	14-00	1-32	4-38
Do.	37-70	—	12-39	9-96	0-0122	0-0280	0-1416	0-6204	0-60	2-27	3-98
Do.		—						0-0470	1-20	0-64	1-57

TABLE 3.

SHOWING IMPROVED CONDITION OF WATER AFTER PASSING THROUGH PIPES.

(Each analysis given is the mean of twenty-four analyses of each water made monthly.)

Mitcham Reservoir	41.03	—	12.00	19.56	0.0037	0.0148	0.1398	0.2348	0.0548	1.11	0.42	1.15
Do. Service pipe	40.91	—	11.90	19.72	0.0019	0.0101	0.1289	0.2156	0.0521	0.89	0.44	0.90
Mount Gambier Lake	40.25	—	11.87	21.08	0.0037	0.0039	0.0073	0.0163	0.0321	0.08	0.02	0.11
Do. Service pipe	40.06	—	11.87	21.06	0.0010	0.0031	0.0060	0.0139	0.0360	0.06	0.08	0.05

TABLE 4.

PURIFYING EFFECT OF EFFICIENT FILTER.

	—	12.78	12.76	0.0007	0.0139	0.1072	0.2200	0.0561	0.50	0.90
Adelaide tap water, 19/9/91	44.40	—								
The same after passing through a										
G. Cheavin's filter	44.40	—	12.73	19.02	0.0007	0.0042	0.0116	0.0296	nil	0.08

TABLE 5.
RESULTS OF VARIOUS SYSTEMS OF PURIFICATION.

Source of Water.	Total Solids.	Solids in Suspension.	Chlorine.	Carbonic Acid Rad. CO ₂ .	Free Ammonia.	Albumenoid Ammonia.	Oxygen Absorbed in Fifteen Minutes.	Oxygen Absorbed in Four Hours.	Nitrogen as Nitrates.	Opacity.	Color.	Comparative Degree of Organic Impurity.
SULPHATE OF ALUMINA.												
Kapunda réservoir	44.40	32.70	1.71	3.06	0.0016	0.806	0.4604	0.8048	0.0760	18.00	15.00	5.94
Do., purified.....	9.30	nil	1.74	0.00	0.0058	0.0102	0.0720	0.1292	0.0650	0.30	0.14	0.40
LIME.—CLARKE'S PROCESS.												
Hope Valley réservoir, March, '89	40.13	—	11.47	18.84	0.0134	0.0380	0.2.80	0.3480	—	—	—	2.43
Do., purified.....	29.90	—	11.57	6.42	0.0080	0.0160	0.1520	0.1680	—	—	—	1.07
ANDERSON'S PROCESS.—AGITATION WITH IRON AND AERATION.												
Adelaide service water of 27/7/93	33.50	—	8.42	14.28	0.0032	0.0180	0.1692	0.3116	0.0515	0.50	1.30	1.48
Do., after settling four weeks ..	31.90	—	8.42	13.32	0.0016	0.0180	0.1344	0.2648	0.0586	0.20	0.90	1.21
Do., purified and decanted after settling four weeks	29.70	—	8.42	13.62	0.0024	0.0080	0.0564	0.1132	0.0779	0.10	0.20	0.27
Do., purified by modified process and decanted after settling four weeks	22.60	—	7.92	5.40	0.0024	0.0055	0.0404	0.0808	0.0779	nil	0.05	0.19

TABLE 6.
ANALYSES OF VARIOUS SAMPLES OF WATER BEFORE AND AFTER HEAVY RAINS.

	46-10 24-80	13-44 7-31	21-84 11-04	0-0010 0-0006	0-0090 0-0030	0-1202 0-1436	0-2008 0-2504	0-0103 0-0344	0-40 0-50	1-10 1-60	0-75 0-96
Mitcham main, April, 1893	—	—	—	—	—	—	—	—	—	—	—
Do. August, 1893.....	—	—	—	—	—	—	—	—	—	—	—
Burnside main, April, 1893	24-00	9-64	4-26	0-0038	0-0040	0-0488	0-0768	0-0085	0-15	1-70	0-19
Do. August, 1893.....	11-40	4-13	2-16	0-0018	0-0091	0-0738	0-0516	0-0102	0-30	2-00	0-41
Magill main, April, 1893	43-40	10-14	24-12	0-0004	0-0030	0-0052	0-0264	0-1296	0-05	0-05	0-06
Do. August, 1893	25-40	6-32	13-26	0-0016	0-0070	0-0444	0-0624	0-1119	0-15	0-25	0-20
Kensington main, April, 1893 ..	27-50	11-04	7-38	0-0052	0-0051	0-0492	0-0836	0-0123	0-40	1-40	0-21
Do. August, 1893..	9-30	3-32	2-04	0-0008	0-0080	0-1024	0-1804	0-0093	0-10	2-00	0-60
Weir at Torrens Gorge, April, 1893	42-70	9-38	23-82	0-0048	0-0110	0-0916	0-1620	0-0260	0-20	0-35	0-57
Do. June, 1893	27-50	5-48	8-52	0-0064	0-0280	0-3312	0-6192	0-0446	1-80	2-20	3-32
Gawler main, February, 1893 ..	134-00	50-76	28-68	0-0013	0-0116	0-0150	0-0312	0-3356	0-00	0-05	0-22
Do. June, 1893	144-20	54-04	31-08	0-0016	0-0120	0-0132	0-0368	0-2995	0-30	0-30	0-22
Port Augusta main, April, 1893..	79-80	23-06	36-12	0-0036	0-0080	0-0136	0-0276	0-0303	0-10	0-15	0-14
Do. June, 1893..	73-80	21-84	31-68	0-0054	0-0090	0-0364	0-0820	0-1688	0-10	0-30	0-24
Wallaroo main,* May, 1893	40-70	7-66	26-76	0-0014	0-0156	0-1708	0-2336	0-0321	0-30	0-10	1-35
Moonta main, June, 1893	72-90	60-80	8-28	0-0026	0-0440	0-6272	1-0464	0-0178	24-00	9-00	6-23
South Para, June, 1891	71-00	24-00	22-30	0-0073	0-0058	0-1140	0-1864	0-0040	nil	0-54	9-68
Do. August, 1891	61-00	22-43	12-60	0-0068	0-0218	0-2216	0-4548	0-0544	0-90	2-30	2-20

*Wallaroo and Moonta are both supplied from the Beetaloo reservoir, and samples taken at the same time are almost identical. The Wallaroo sample was, however, taken before and the Moonta after the flood, and show the effect of flood water.

TABLE 7.
BACTERIOLOGICAL.—GELATINE PLATE CULTURES.

Source of Water.	No. of Liquefying Colonies per cubic centimetre.	No. of Solid Colonies per cubic centimetre.	Remarks.
Tap water, Adelaide supply	140	180.	Liquefied before counting
Tap water, after standing 21 days	—	—	
Water, purified, standing 1 day	15	87	
Water, purified, standing 1 day	—	15	
Tap water, after standing 2 days	—	180,000	
Purified water, after standing 2 days	—	—	Quite liquefied in 2 days
Purified water, after standing 2 days	—	—	Did not liquefy
Purified water, after standing 2 days	—	—	Did not liquefy
Tap water, after standing 3 days	—	5	Quite liquefied fourth day
Purified water, after standing 3 days	—	22	Part liquefied fourth day
Purified water, after standing 3 days	—	—	Trace liquefied fourth day
Purified water, after standing 3 days	—	—	All liquefied fifth day
Tap water, after standing 4 days	30,000	10,000	
Purified water, after standing 4 days	102	250,000	
Purified water, after standing 4 days	167	400,000	
Tap water, after standing 7 days	14,200	45,000	
Purified water, after standing 7 days	36	720,000	
Purified water, after standing 7 days	442	680,000	
Purified water, after standing 7 days	?	?	All liquefied fourth day
Tap water, after standing 14 days	1,314	340,000	
Purified water, after standing 14 days	nil	nil	Kept for weeks without a single colony developing
Purified water, 9in. from surface	—	—	
Tap water, after standing 21 days	322	125	Liquefied quickly
Purified water, after standing 21 days	544	28,000	Only slightly liquefied after 7 days
Tap water, after standing 38 days	161	760	Liquefied quickly

Purified water, after standing 38 days	255	11,000	Liquefied very slowly
Tap water, after standing 49 days	115	920	
Purified water, after standing 49 days	—	7,164	
Tap water, after standing 63 days	422	363	All liquefied after 4 days
Purified water, after standing 63 days	—	1,071	Three species
Tap water, from 9in. deep, after standing 8 weeks	4	14	

TABLE 8.
BACTERIOLOGICAL.—GELATINE PLATE CULTURES.

Source of Water.	When Drawn.	Liquid Colonies per cubic centimetre.	Solid Colonies per cubic centimetre.	Further Colonies.	Remarks.
Adelaide service	August 7th, 1893	13	62	—	Liquefied quickly
Do. service	August 16th, 1893	42	173	—	“
Do. service	August 23rd, 1893	26	51	—	“
Do. service	September 4th, 1893	78	125	80 solid	Twelve species counted
Do. service	“	12	6	—	Cultivated in coal gas
Kensington service	September 12th, 1893	19	20	+ 8L-29s	Total 76 colonies
Burnside service	“	20	21	+ 6L-18s	Total 85 colonies
Magill service	“	3	24	+ 14L-23s	Total 64 colonies
Mitcham	“	45	221	—	Too liquefied to count
Adelaide service	“	136	180	—	“

† L stands for liquefying, S for solid colonies.

3.—HOSPITALS AS A MEANS OF SPREADING A
KNOWLEDGE OF SANITARY LAWS AND
HYGIENE.

By Miss NOBLE.



4.—ARTISAN DWELLINGS, WITH SPECIAL REFERENCE TO THE CLIMATE AND CONDITIONS OF SOUTH AUSTRALIA.

By A. H. GAULT, M.B., M.R.C.S., L.R.C.P.



5.—REASONS FOR CONNECTING THE HIGH DEATH RATE OF ADELAIDE AND THE INCREASING UNHEALTHINESS OF SOME OF THE SUBURBS WITH SEWERS AND SEWER GASES.

By Miss MARTIN.



6.—NOTES ON SPIROPTERA ASSOCIATED WITH TUBERCULOSIS IN CATTLE.

By C. E. BARNARD, M.D., and ARCHIBALD PARK, M.R.C.V.S.

During the winter of this year Mr. Park was requested to examine a herd of cattle in the Burnett district of Queensland, as many of them were found to be suffering from swellings and tumors, thought to be due to tuberculosis, and called locally "lumpies." Seventy head were slaughtered for the purpose of examination, all in a more or less diseased state. Tumors and abscesses, varying in size from a walnut to a cocoanut, were found in all parts of the body, throat and neck, brisket, intestines, &c.; and while some were hard, others were softened down into purulent matter, but in each case the contents were encysted in a firm fibrous cyst wall.

Without the use of the microscope in these cases it would be difficult to diagnose the true nature of the cause of these singular growths and abscesses, as in many features they resembled tuber-

cular masses, or those swellings due to the presence of actinomyces ; and as pleuro-pneumonia had been reported to have been prevalent in Queensland, it was a natural inference that this condition had left behind lesions which would lead to the production of tubercular deposit in the system, especially as tuberculosis is found to be so prevalent in Queensland. Approaching the investigation of these tumors from a tubercular point of view, it was surprising to find them entirely due to the presence of a parasitic worm, which resembled the *Spiroptera reticulata* of the horse. Under a low power of the microscope calcareous worm casts were discovered amongst the *debris* of the purulent matter which escaped from some of the abscesses when cut open. Further examination disclosed the nature of the worm, which was seen to be of a filiform shape, with serrations and transverse markings. Only fragments of the worm could be obtained, as apparently the whole adult worm could not be extracted. Where the tumor was not broken down the worm was found to be alive, and, upon a cover-glass preparation being made from the section of one, innumerable ova and embryos were noted.

Upon using various stains tubercle bacilli were found mingled with the *debris* of the broken down tissue, showing that we had to deal with tuberculosis in addition to a worm disease. One very important fact was noted, that no cattle under two years of age were found to be suffering from these tumors, leading one to believe that we were dealing with a parasite that takes a considerable time—a year or more—to develop and cause mischief.

Up to the present time no great importance has been attached to this parasitic worm disease, as it was not considered to be of a dangerous or infectious character ; but we believe that it will be found to be very prevalent throughout the colonies which obtain their cattle from Queensland.

In that colony human beings suffer from cold abscesses, which are apparently mysterious in their origin. It is probable that this parasitic worm plays an important part in their production. A description of these cold abscesses in the human subject given by Dr. Thompson is identical in every respect with the abscesses found in cattle due to the worm, as they are singular in this respect—they are enclosed in a cyst—there is no burrowing, but the pus is contained within a capsule, and until the walls become attenuated or broken by injury there is no discharge of the matter. As tubercle bacilli are always associated with this disease—possibly secondary to the parasite—the danger to the system of these tumors is obvious ; so, even if the matter were allowed to escape, and the pyogenic membrane scraped and the wound to heal, there would still be the tubercle bacilli to deal with. This constitutes one of the dangers, as tubercle bacilli find in these nests a suitable nidus for their growth and multiplication, and so gradually produce general tuberculosis.

In tropical countries, such as Queensland, parasitic worms abound, as well as tuberculosis; but in the temperate climate of Tasmania worm nests and tuberculosis are unknown amongst cattle that are native bred, these diseases being only found in animals imported for food. In South Australia, from observations made some years back, we believe that the same diseases will be found amongst the cattle.

With regard to the possible transmission of this parasitic worm to man, we believe that this is quite possible by the ingestion of the flesh of animals suffering from this disease, but that it is more than probable that the disease is communicated by drinking contaminated water. Apparently no intermediate host is required or exists to complete their development, as the embryos seem perfect even in the oviduct, the transverse markings being distinctly observed. The embryos are about $\frac{1}{100}$ th of an inch in length, and we find them in the surrounding tissues of the tumor, scarcely distinguishable from elongated nuclei. They are uniform in shape from head to almost the extreme point of the tail. When grown into the adult form the transverse markings are found to be rugate, ridges running across as well as longitudinally. This is the best noticeable in the fresh state. The outline of its body shows these ridges as a serrated edge, which is very characteristic of this worm. The two oviducts and intestinal canal are plainly visible in the adult worm under the microscope, and in the oviducts are easily seen the ova and embryos in various stages of development. Only fragments of the adult worm have as yet been extracted, as the whole length is coiled up in the nests, and are so surrounded with fibrous tissue, and locked up so firmly, that it is impossible to extract or uncoil any great length. The portions removed resemble bits of thread. A section of a small tumor or nodule containing the worm has a perforated or reticulated appearance, and hence the name *Spiroptera reticulata*. Hitherto the head of the adult worm has not been found owing to the difficulty of extracting it from its fibrous bed, but Mr. Park has succeeded in obtaining from the debris of the pus from one of the tumors, by careful washing, a head which is remarkable in appearance, and which agrees in all particulars as regards size and shape with the rest of the parasitic worm; but until more than one is obtained there is not sufficient evidence to show that this head belongs to the particular worm under observation. This head that has been found has teeth-like projections and briar-like barbs encircling in a spiral manner in numerous rows, thus presenting a formidable appearance. Should such a head once become fixed, it would remain, as it would be difficult, if not impossible, for it to be extracted. The system once invaded by this worm is ever at its mercy. The measurement of the adult worm is difficult, as only fragments can be obtained; but if we count the number of transverse markings on the embryo, and by means of a micrometer measure the space

within which an average number of striæ are contained, we have a basis for measurement of the worm. We find that an embryo has at least 400 markings. When grown into an adult the markings must necessarily become more widely separated from each other, and as the average number—400—must still be the same if we measure the distance apart of any two striæ and multiply this measurement by 400 we roughly obtain an average length of the adult worm. By some such measurements we find that an adult worm would measure at least 36in.

After we had so far proceeded with our investigations into the life history of this parasite the last volume of the Transactions of the Third Session of the Intercolonial Medical Congress, held in Sydney last year, came to hand, wherein we noticed for the first time that Dr. Gibson had investigated the same worm and had read a paper upon the subject at the Congress, and illustrated his remarks with drawings of the microscopical structure of the worm and its ova and embryos. Although Dr. Gibson does not think that it is communicable to man, by reason of experiments that he made, yet its importance cannot be overlooked when the statement is made that "50 per cent. of the animals slaughtered in Sydney" are found to be affected with these "worm nests." Even if it be granted that this parasite cannot be transmitted directly to man by the ingestion of the flesh of animals suffering from this disease, it cannot surely be denied that when these tumors break down into large suppurating masses the meat from such a diseased animal must be quite unwholesome, and probably unfit for human consumption.

As a practical outcome of our investigations into this as well as other diseases of animals used for food, we are of opinion that at every abattoir most rigid inspection of animals at time of slaughter should take place and the viscera carefully examined, and if any suspicious disease appeared the matter should be referred to the opinion of an expert pathologist for his decision as to the nature of the disease.

NOTE.—Since the paper and specimens were forwarded to Adelaide Mr. Park has found in sections recently obtained the young *Spiroptera* in some of the blood-vessels. He is now satisfied that they are carried by the circulation and deposited in all parts of the body, more especially the internal organs.



7.—DISPOSAL OF TOWN REFUSE BY DESTRUCTION.

By J. A. HARDY.



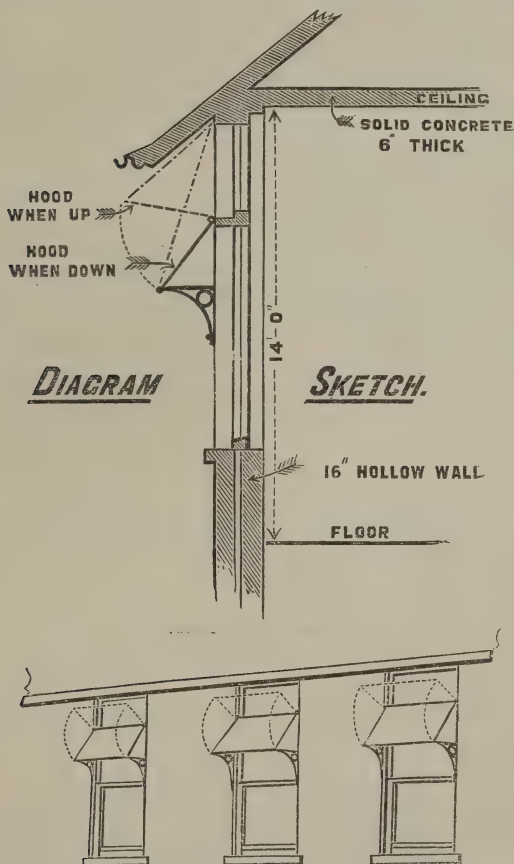
8.—A NOTE ON THE CONSTRUCTION OF HOSPITAL WARDS.

By JOHN SULMAN, F.R.I.B.A.

The planning and arrangement of hospital wards is a subject to which so much attention has been directed that it may appear at first sight there is little or nothing new to be discussed in connection therewith, but a suggestion of our respected President has led me to consider whether the most suitable type has yet been evolved for the temperate and semi-tropical regions of Australia. That which we are accustomed to was developed and perfected in Europe and North America, where the winters are more or less severe, and every ray of sunshine during that season is of so much value that a little excess in the summer is not noticed. But in this southern land we have almost too much sunshine, and the tendency is to screen ourselves from the too ardent rays of the source of heat and light. Modern investigations seem, however, to prove more and more clearly the efficiency of the direct rays of the sun in destroying the germs of disease, and the problem in ward design is, therefore, how we may secure direct sun action, when and where required, and at the same time minimise the evils of too much heat and glare. Now let us consider for a moment the external structure of a ward. It consists of windows, walls, and roof, through the former of which both heat and glare penetrate, and through the two latter heat alone. Taking the windows first, their position between the beds is fixed beyond discussion, and their height, it is generally agreed, should be from about 2ft. 6in. or 3ft. above the floor to the ceiling line. May, however, their width be decreased as compared with those in the northern hemisphere? This would reduce the amount of light on a bright summer day, but not its intensity, and in winter time would be found objectionable, as insufficient light would be admitted. The facilities for through ventilation would also be decreased. Internal blinds do not seem to me of much service, because, though they modify glare, they are of little service against heat, and also stop ventilation. External verandahs which cover both windows and walls are effectual against heat and glare, but fatally defective in permanently cutting off the direct rays of the sun.

A modification of this system, as seen at the Prince Alfred Hospital, Sydney, and elsewhere, is the reduction of the height of the verandah so that a small upper window gives direct admission to sunlight, and the remainder of the window and wall space is permanently shaded. This is suited to an intensely hot and bright climate, in which cloudy days are rare, but where they frequently occur the wards are more or less gloomy, and the amount of direct sunlight available is small in quantity and cannot be increased at will. External venetian shutters of the kind wherein the *louvres* are movable offer some advantages, as they can be set to admit any amount of light from the minimum to the maximum. They

also permit of free ventilation, but they are not proof against heat, are prison-like in appearance, and require a good deal of attention in opening or closing to suit the light at different hours of the day. I now venture a suggestion to meet the difficulty. Let the windows have a small top light shaded by the eaves. During the hotter months when the sun is nearly vertical let the lower and greater length of window be covered by a hood, as shown on the sketch, capable of being drawn up to any required angle, so as to



PERSPECTIVE SKETCH.

admit more and more sunlight up to the maximum. This could be effected simultaneously on each side of a ward by means of a

continuous rod and gearing such as is used to open a series of fanlights, but with a small drum fixed above each window for the hood suspension chain to wind up on. Each hood could also be operated separately by a simple mechanical arrangement, the brackets supporting the hoods to be fitted with spring catches so as secure them in case of storm or heavy winds. By this system the glare of direct sunlight during the hottest portion of the day in summer is obviated, while in winter full advantage can be taken of the sun's rays. There is also no obstruction to outlook or ventilation, and the cost of such an arrangement would certainly not exceed that of a verandah. But this mode does not shade the walls as a verandah does. True. And a solid brick or stone wall well heated by the sun renders the interior of a ward almost intolerable on a hot summer day. A hollow wall, however, at once meets the difficulty. I am writing this note in one of the hottest towns of New South Wales, and close to a building erected from my designs a few years since with hollow walls. I have just been assured by its occupants that it is the coolest building in the town, though exposed to the full glare of the sun all round. First introduced to resist driving rain, hollow walls will prove extremely useful in securing coolness as well. As regards the roof of a ward, I advocate a solid ceiling of light steel joists filled in with cement concrete and a light roof over quite open to the atmosphere at the eaves and ridge. The greater the heat the quicker the circulation of air through the roof, and the cooler the ward below becomes. In winter time when cold winds are blowing the solid ceiling is thick enough to prevent any reduction of the temperature inside the ward.

These suggestions I beg to offer for the consideration of medical experts, and my only regret is that I am unable to attend the meetings in person to join in the discussion and profit by criticism.



9.—A NOTE ON THE AXIAL LINES OF HOSPITAL WARDS.

By JOHN SULMAN, F.R.I.B.A.

In Europe and the Northern States of America it is the recognised rule that the axial line of a rectangular ward should be north and south, thus securing the maximum of sunshine on both sides of the ward during the day. But in Australia the elevation of the sun and the intensity of its rays is greater, and the question has occurred to me whether it is desirable that the rule just referred to should be followed, as I believe it is in most cases. In

summer especially it is advisable to keep the wards as cool as possible without shutting out light. If the flanks are exposed to the morning and evening sun they receive the maximum amount of heat, for the sun shines directly upon them, whereas at midday it is almost vertical, and the projection of the eaves is sufficient to throw the walls into shade. Suppose, however, the axial line be east and west, then one end only being usually free and the other screened by accessory rooms a minimum surface is exposed to the level rays of the sun. One flank or side will be moderately hot and the other cool for nearly the whole of the day, and the natural ventilation of the ward will thus be materially assisted—a result not attained by the north and south axial line, as the eastern side, which received the sun's rays during the morning, would not cool down before nightfall, and thus both sides during the afternoon (the hottest part of the day) would be very hot. It may, however, be urged that in winter the north and south axial line would offer the most advantages, but, considering the clearness of our atmosphere, the warmth of the sun's rays, and the lower elevation above the horizon, the east and west axial line would permit of a rectangular ward of the usual type being thoroughly sunned. On the whole, therefore, it appears to me that the balance of advantages lies with the east and west axial line instead of the north and south.

Section J.

MENTAL SCIENCE AND EDUCATION.

1.—THE TRAINING OF SECONDARY TEACHERS.

By P. ANSELL ROBIN, M.A.

In view of the increased interest taken by the more prominent teachers in the theory and the intelligent practice of their profession, it needs no apology to press upon their attention what is the greatest problem in secondary education—a problem whose successful solution will involve the most far-reaching reforms in our present systems. The Teachers' Guild, in England, has for years recognised as one of the chief principles underlying its activities that some sort of special professional training is necessary for teachers of every grade. It is devoutly to be wished that each of our Australian guilds would make this a central plank in its platform, and would concentrate its energies upon the work of training our secondary teachers.

It is easier to carry conviction in the case of an abstract proposition than to suggest an acceptable scheme for remedying acknowledged faults. The difficulties that stand in the way should, perhaps, first be briefly stated. (1) A workable scheme must be adopted by at least a large majority of headmasters, and as each school is absolutely autonomous, and almost independent of public opinion, it may be very difficult to secure the co-operation of an influential majority. (2) The aid of the universities is absolutely necessary for any adequate system of training secondary teachers, and the necessity for devising a plan that will commend itself to these academic bodies also introduces another element of complexity. (3) Even when, by the concurrence of the professor and the schoolmaster, provision shall have been made for preparing candidates for educational work, some sanction will be necessary in order to prevent the scheme becoming a dead letter. Either there must be loyal unanimity of all who control our teaching institutions, or the system will have to be safeguarded by legal enactment. The latter of these alternatives would require the education of public opinion to act for this end through its Parliamentary representatives, and this perhaps would be the hardest task of all. Recognising therefore the obstacles that beset the path of reform, let us ask whether a practical scheme could be formulated without unduly interfering with the existing conditions of our schools. We may dismiss altogether from our thoughts the idea of having training colleges for secondary teachers. If training necessarily involved the herding

together of intending teachers in an atmosphere surcharged with pedagogic wisdom and priggishness (which is the idea many people have of training colleges), I for one should infinitely prefer the present chaos. But even if they were desirable, there is no agency in Australia that is likely to establish them, and no fund by which they could be maintained. It may be taken for granted that a course of professional training must be both theoretical and practical. For the theoretical we must look to the university, for the practical to the school; and neither institution need be remodelled in order to supply these new demands. In each of our universities at the present time professorial lectures are given in psychology, ethics, and physiology — the educational sciences. The only additional course of lectures to be supplied would be in the history of education, and some member of the existing staff could probably in each colony be found to undertake this. Attendance at these lectures should be made compulsory upon all intending teachers, even (I might almost say, especially) if they are already distinguished graduates; for the great heresy which must be combated in all its forms is the idea that intellectual attainments are of themselves sufficient equipment for teaching.

The practical part of the course can only be provided by existing schools, and here is another difficulty. Not all headmasters will be disposed or (may it be said without rank blasphemy?) even competent to superintend the work of student teachers, to help in difficulties, to suggest fruitful ideas, and stimulate to self-improvement; yet this, it seems, is not only desirable but even essential to any practical scheme of training. Would it be possible to admit, on probation, those who are recognised as merely learning to be teachers? The question with head masters will be—How can we make room for them when our staff is already complete and the work mapped out? It is partly a matter of expense and partly one of organisation. If, however, a year's actual teaching were universally required before admission to full work and regular status, probationers might well be expected (as in certain other professions) to be content with nominal remuneration while thus qualifying themselves. If room were afterwards found for them on the regular staff of the schools where they have been trained an enormous advantage would be experienced by headmasters in having assistants to whom they have imparted their own spirit and their own methods.

The present system has naturally perpetuated itself. Headmasters have not felt able to insist on their assistants receiving a preliminary training, because their choice would then be exceedingly limited. On the other hand, university men will not subject themselves to preparatory discipline for the teaching profession, because they are sure of admission somewhere without it. It is easy to understand the reasons for this: a man fresh from the university presumably brings with him a breadth of intellectual

sympathy, a freshness of spirit, a strong (if often superficial) sentiment in favor of culture, which are, not without some reason, held to compensate for the absence of any acquired fitness for educational work. But on the whole the system is a great mistake. This is why a writer in the "Cyclopædia of Education" can remark that "teaching in secondary schools is rather looked upon as an avocation than as a profession." Professor Laurie (of Edinburgh), in his "Life of Comenius," breaks out into the exclamation:—"How are the best traditions of educational theory and practice to be preserved and handed down if those who are to instruct the youth of the country are to be sent forth to their work from our universities with minds absolutely vacant as to the principles and history of their profession—if they have never been taught to ask themselves the questions, 'What am I going to do?' 'Why?' and 'How?'"

Let us by all means continue to secure for our secondary schools as large a proportion of university men as possible. Let us add to this a universal demand for professional training, received partly in the atmosphere of the university, partly in practical work under our most cultured and experienced teachers. We shall then improve our educational methods by placing them on a scientific basis; we shall justify our teaching institutions in the eyes of the community, which now with too much justice discounts the labors of educationists; and we shall raise the calling of a teacher to a nobler position as a learned and scientific profession. "Experience," we are told, "keeps a dear school." How long will critics be able to add, "and schoolmasters will learn by no other"?



2.—PUBLIC INSTRUCTION AND PUBLIC DEFENCE.

By JOHN SHIRLEY, B.Sc., Inspector of Schools, Queensland.

Drill, in Queensland, is a compulsory subject in all elementary schools. Introduced by the State Education Act of 1875, its aim at that date was merely to act as an aid to discipline, and its other uses were to a certain extent ignored. The text book selected—Norman's "Schoolmasters' Drill Assistant"—was not in accord with the manual used by the military forces in Queensland, and the so-called "extension motions" were almost useless as a means of physical training. There was no provision in the regulations published with the Act of 1875 for the formation of cadet corps, or for anything higher than squad drill, and it depended on the efforts of individual teachers whether the higher forms of military drill were attempted or not. The need for physical training was recognised

almost from the introduction of the Act, the utter uselessness of the "extension motions" requiring no demonstration. In Brisbane an instructor in gymnastics was appointed, and the playsheds were fitted with gymnastic appliances. All senior boys were placed under instruction, the time each week varying from one to two hours. A most capable man was employed; teachers and children entered heartily into the work; much private practice was indulged in; and yet the training did not confer generally the beneficial results that were desired. In addition to the time set apart for gymnastics one-quarter of an hour each day was almost universally devoted to the teaching of squad drill, and to this may be added the time spent at change of lessons, which changes were invariably effected by some adaptations or combinations of drill movements. From the drill lessons no healthy child, however young, was excepted, and every class, from the lowest rank in the infant school to the highest in the boys' and girls' departments, had to undergo examination in this subject at the annual inspection. As an aid to discipline the teaching of drill was found of the highest value; it enforced attention, prompt obedience, and unanimity of action; it made class changes precise and orderly; and it brought class movements to a remarkable state of steadiness and uniformity. When the regulations of the Queensland Department of Public Instruction were revised in 1891 the defects in the scheme of physical training were recognised, and it was determined that gymnastic exercises should be required not only in town schools, but in all State schools receiving Government aid. The former text book for drill was discarded, and in its place was substituted the book of "Infantry Drill" used by the British army and by the colonial forces, and through this change the squad drill was made to agree with similar work taught to the defence force and volunteers. In the place of the "extension motions" the setting up drill of the army, *i.e.*, the "physical exercises," were required. Each exercise is specially devised to train a certain set of muscles, and, as they may be taken without arms, or with dumb-bells, dummy muskets, or firearms, they may be made suitable for pupils at all stages. School inspectors and teachers received special instructions in the physical exercises, being gathered in squads at the barracks and drill-sheds throughout the colony, and taught by the sergeant-instructors of the defence force and volunteers. This form of training became, and continues to be, most popular. Public displays were given by the various squads of teachers at the end of their training, and then they were disbanded to commence similar teaching in their own schools, or classes. Throughout the colony the boys and girls take great pride and pleasure in this branch of gymnastics. No school treat or arbor day festival is complete without an exhibition of physical drill; and public competitions between neighboring schools keep up a generous rivalry and emulation. At assembly, at dismissal, and in the intervals

between lessons, one or more of these exercises may be taken, and the effects on the carriage and development of children have been far more valuable than those observed when the gymnastic classes were in operation.

The changes introduced by the regulations of 1891 benefited the teaching of drill by bringing it into accord, as far as it went, with the drill of the army, by improving the muscular training, and, lastly, by providing for the formation of cadet corps. In all large schools battalion drill is taught in addition to squad drill; and, where there is no cadet corps, the dummy muskets employed in the physical exercises are also used in teaching the manual exercises. The male teachers of Brisbane and neighborhood have formed a volunteer corps, and this, though of recent formation, has received considerable praise from the commandant. Already there is a question of forming a second company, as the one now in existence is becoming too large, and the example of Brisbane teachers will doubtless extend. But with all this preliminary work there is not yet any public or official recognition of the third great use of drill in State schools—I mean the training of the youth of the colony to take their share in the defence of their country against foreign attack.

In Switzerland—a country shut in by the four great military powers, Germany, France, Italy, and Austria—it has been found possible to make the drill taught in the elementary schools of the utmost value in the general scheme of national defence, and by its help to minimise the cost of annual training, while developing to the full the armed strength of the nation. Drill is a compulsory subject in all schools and colleges receiving State aid or recognition throughout Switzerland. From six to twelve years of age in the elementary schools, and from twelve to fifteen years in the canton schools, every Swiss boy receives military training, with a view to fit him for active service in the field when he attains to manhood. From twelve to fifteen in the secondary schools and canton schools he is drilled in corps similar to our cadet corps, and takes part in the manœuvres of the military forces of his canton. So complete is his training as a child that, when called to the colors at the age of twenty, he has only to undergo about two months' training the first year, and a fortnight's drill each successive year, until he has reached the age of thirty, to keep him in a state of efficiency; while, to maintain the national skill in marksmanship, the men between twenty and thirty are called out at intervals, chiefly on holidays, for practice at the butts. From thirty to forty the Swiss are still liable to military service in time of war, but in time of peace they are not required to leave work or business for purposes of drill. French and German experts speak in laudatory terms of the Swiss military organisation, and regard it as economical and efficient. This practical use of the drill taught in elementary schools has no such thorough application in Australia, although Victoria and New South Wales by their extension of cadet corps are as usual leading the way.

In Queensland the boys in our elementary schools have a natural liking and aptitude for drill, and the same inclination may probably exist in other Australian Colonies. As far as intelligence is concerned I should be sorry to suppose that the pupils in our elementary and secondary schools are in any respect inferior to those of Switzerland, and already officers of the Queensland forces perceive the beneficial effects of school drill in lessening the time and trouble of training recruits. That which is impressed upon the child by constant repetition is never forgotten, and the boy learns with pleasure the elements of drill, which are monotonous and distasteful to the adult.

It is usually laid down as an established fact that conscription will not be borne by men of Anglo-Saxon race, but I am not advocating conscription; arbitrary selection is invidious, however decided. My contention is for universal military service. By following the Swiss plan we obtain the benefits of conscription without withdrawing men for lengthened periods from their farms and workshops, but this can only be possible when it is plainly recognised that the military training of our youth commences immediately upon enrolment in our schools. Compulsory military service is by no means unknown in English history, or in English colonies, and by restoring it to the statute book we are merely returning to customs of our forefathers, which have become obsolete through accidents of position and good fortune. Already in Queensland the adult male population can be called out in levies for military service when the colony is threatened.

It is not in the province of this paper to deal with military affairs further than they concern the schools supported by the State, but I think that children should be taught to feel a pride in their native or adopted country, and should be led to recognise that it is the duty of every man to assist in its defence when threatened by foreign invaders, and should also understand that he who has failed to train himself for military service when the day of danger comes is not fitted for the rights of citizenship, however estimable a man he may be in other respects.



3.—THE APPOINTMENT OF A JOINT EXAMINING BOARD FOR THE UNIVERSITIES OF AUSTRALIA.

By Rev. Canon POOLE, M.A.

Federation, we are told, is in the air, but there is no reason why it should stay there, and possibly it is not desirable that it should be brought about in a hurry. It will be in the end achieved, if

achieved at all, by the operation of small and tentative processes which will enable the various colonies to discern the strength which comes from union and the advantages which are derived from co-operation.

The object of this paper is to show that it is desirable that some efforts should be made to secure in some measure, and for certain purposes, a federation of the Universities of Australia. When one first approaches this subject of federation of the universities one is apt to rush to the conclusion that a complete federation is the thing that ought to be aimed at, or else to come, somewhat hastily, to the opinion that one university would be sufficient for the whole of Australia. I confess that at one time I held to the latter opinion. It seemed to me preposterous that a population of some 4,000,000, the large bulk of which is engaged in the development of a new country, and forced by their circumstances to be busy with the satisfaction of their material wants, should require so many seats of learning; but closer observation seems to teach that the foundation of these institutions is warranted by facts. First, there is the wide distances which would have to be travelled by students from Melbourne and Sydney if the sole university were, *e.g.*, in Adelaide; secondly, there would be the loss of inspiration which a local institution breathes; and, thirdly, there is the fact that the various colonies are rapidly developing an *ethos* of their own, and this will be best fostered, encouraged, and directed by those who best understand it. Neither does it seem to my mind expedient that the universities should be bound together by too closely binding a tie. In days when socialism in everything is, rightly or wrongly, widely and loudly advocated it must not be forgotten that individualism has some rights and claims. The individuality of local tone and local color already observable in all the universities should, I venture to think, be to some extent preserved. I, for one, do not wish to destroy it, but I do think that great advantages would accrue to the three seats of learning in Australia if joint examination boards were appointed to conduct the examinations for degrees. But, it may be asked, why only do this for the examinations for degrees? Why not have joint boards to examine in the yearly examinations? He is an unwise general who, in leading, goes too far in advance of his army. I do think that much would be gained by having all examinations conducted on a joint system, but I do not wish to go further just now than I am likely to have followers; and besides, I see more difficulty in the latter cases than in the one I have now in hand.

As an abstract proposition, I fancy that few would object to the correlation of the universities *quoad* their *curricula*. Their object, I take it, is one and the same, *viz.*, the promotion of sound learning; and the means whereby they seek to attain their object is much the same, *i.e.*, broadly speaking, the same subjects, both qualitatively and quantitatively, are taught and tested; and, as

regards degrees, it may be roughly stated that they represent a hall-mark of proficiency which, with few exceptions, passes current throughout Australia. I know that in one university certain branches of study are more thoroughly taught, and presumably learned, than in another. It would be invidious for me to particularise further than this; but let me say, for argument's sake, that Sydney is strong in science, it may be; Melbourne, in classical culture; Adelaide, in mathematics. (I do not say this is the case, but I put it thus by way of illustration.) Various causes may contribute to this, as, *e.g.*, the encouragement of a certain line of study at the secondary schools, the ability or enthusiasm of an individual professor, or the rewards or inducements held out with the view of encouraging the pursuit of knowledge in a particular direction. But whatever may be the *differentia* in the courses of the various universities, and to whatever extent they may be followed, it does seem to me to be pre-eminently desirable that the degree in any given school should connote, as far as possible, equal attainments throughout all Australia.

Again, on the ground of saving of labor, I advocate the appointment of a joint board of examiners. At about the same time of the year, in every year, some twenty gentlemen of high education, whose time is therefore highly precious, are seated at their twenty respective tables, holding in their respective hands their twenty respective pens, and preparing their twenty respective papers—all of which might be just as well, possibly better, done by some half a dozen of them; and then, when the candidates have handed in their papers, these same twenty gentlemen will — But there, I throw a veil over the rest of the performance, for no one who has experienced the tedium of looking over a large number of papers, loves to have it recalled, even to memory. Now, why could not the papers in, say, the subject of mathematics be prepared by the three professors of mathematics acting together, or by one in one year or one in another? There would then be no need for calling in an outside examiner for the purpose of checking the work of the professor, a course to which so often so much exception is taken. The papers of the candidates would be reviewed by each of the three professors and marked by all, and the *mean* marks might be taken as a final result.

It is not held to be right that a judge should adjudicate on his own case, or that a man should audit his own accounts, and yet the examinations in question are largely conducted by the actual teachers of the scholars; the test made by them may be a fair one—it may not; at any rate, a body of gentlemen like the professors should be placed above suspicion, and this would be done by the plan I have suggested. Again, it would be foolish to expect that all those who occupy positions on the professoriate should be equally enthusiastic, painstaking, energetic, and I will add, if I may, equally conscientious; they are but men, and they differ as do

other men. For my own part, I rather like the idea of a learned, dreamy professor, whose thoughts are so often in the higher regions that they cannot readily be brought to bear upon the lowlier and more practical work of life; and it is a distinct loss to Australia that no place is at present found for learned leisure and for the endowment of original research. The force of circumstances requires that the professors should be working teachers, and it would be wholesome for them that they should be kept well up to the collar by outside stimulus. I say this because I think that all men, except in the rarest instances, require it. The experience of other men may be different from my own; my own observation, as well as my own feelings, warrants me in saying that comparatively few men love work for its own sake. In this way a great guide would be given to the governing bodies of the universities; these, as we all know, are not exclusively nor necessarily composed of gentlemen who are skilled to gauge the actual work done by the teaching staff of the university. They have to trust, and they are justified in trusting, to the unimpeachable integrity of their professors, but, nevertheless, it would be a decided advantage to them to be able to convince others of a fact well known to themselves by the corroborative testimony of external and therefore completely unbiassed examiners. Much also may be said in favor of the adoption of such a scheme on the side of the professors. I have already hinted at the drudgery of examinations; it may not be possible to relieve them altogether of this arduous and distasteful task and leave them to their proper work of teaching, but we may make it as small as possible. Then, too, how perplexed a professor must often feel when examining the papers sent in by his own class. He cannot help having certain opinions, favorable or otherwise, concerning individual members of his class; he cannot well be expected to be without prepossessions, and if, as may sometimes happen, some outsider, some non-collegiate student, of whom he knows nothing, is examined at the same time, and with the same papers as those of his own class, he will be a sanguine man who imagines that he has acted with equal justice to all.

It may be that the importance which they deserve has not been accredited to these Australian degrees; still that they are important none of us will question. They form the portals of admission in some cases of high and responsible civil engagements, while of their value to students of law and medicine it is unnecessary to say anything. We shall best preserve the value set upon our degrees, and indeed help very greatly to increase it, by using every method we can to keep the standard at a fair and equable level. This standard should, I venture to think, be the same for all. The degree in any given school should represent all over Australia equal attainments. Intercolonial courtesy and, I may add, intercolonial necessities seem to require that there should be the fullest reciprocity between the universities of Australia. It is right and proper that

in the republic of letters there should be as ready a recognition as possible of the members who belong to it, whithersoever they may travel, and therefore it is that those who are the fortunate possessors of degrees of recognised value are admitted *ad eundem gradum* without difficulty. Again, the population of Australia is a vagrant and shifting one; young men especially do not here and now feel themselves bound by a very close tie to the country of their birth and education. It is only fair that they should be able to claim the same position in the university of the land of their adoption as they held in the land of their birth. But if their degrees are not of equal value—are not a measure of the same acquisitions—then it is plainly unfair and unjust that *ad eundem* should be granted at all.

In order to effect that which I am now advocating it would first of all be necessary that there should be a more or less general agreement on the general lines and the extent of the various branches of study. It is not my intention at this stage to go into detail; suffice it to say that I have compared the *curricula* of the schools of the universities of Sydney, Melbourne, and Adelaide, and I do not find that there is any very great difficulty to be anticipated on that score; indeed, in some points in which Adelaide is differentiated from the other two I feel sure that we shall have to make some alterations, and, indeed, I know that others as well as myself have contemplated taking action in this direction, and it is perhaps possible that our distinguished sisters of Sydney and Melbourne might find some points worthy of imitation in the modest little University of Adelaide. Indeed, I was informed not very long ago that Melbourne was discussing the advisability of doing what was done here some years ago, viz., abolishing the matriculation examination, and instituting others analogous to our junior and senior examinations. The more each university can learn from the others the better it will be, and if by joint operation it will be possible to incorporate into *one* system the peculiar advantages of the three it must prove a benefit to all.

I come now to the consideration of the more palpable advantages which would flow from the adoption of some such scheme as I have shadowed forth.

1. In an indirect way each university would benefit by the learning of all the professors, the papers being the same and the standard the same. The students would in those cases where at present they are below the standard feel the necessity of making efforts to reach it.

2. The knowledge that the papers for his degree would be referred to the most learned men in Australia, men unknown to him, perhaps, except by reputation, and so not belittled by common every-day acquaintance, could not fail to be a stimulus to more thorough scholarship.

3. There would on the certificates of the degrees be the same watermark traceable which all would know, all recognise, and all hold in due and proper estimation. We cannot manufacture antiquities; traditions are the growth of time. We cannot expect that the degrees of Australian universities shall have that prestige which attaches to a long history and a glorious succession, but if corporate action in this matter were agreed to the value of an Australian degree would rise 50 per cent. in value.

4. That a clear and definite value should mark all degrees is desirable, but that honor of degrees should be so marked is essential. It may be taken for granted that in the future the chairs in the universities will be filled by Australians, and that a great many other influential posts which are now filled by gentlemen from older countries will also look to the Australian universities for their supply. A common standard and a common register should be fixed and made so that it may be known at once what a man's qualifications for any given position really are. That there should be a single honor list for all Australia, a list which might supply the place to Young Australia of the famous class lists of Oxford and Cambridge, would be a distinct incentive to the noblest of our youth, and if Fame be

The spur that the clear spirit doth raise
To scorn delights and live laborious days

then we should have in course of time in these class lists a roll of honor, which would be likely to fire the imagination of the young Australian and teach him that there are other things worthy of his ambition than kicking goals and making "centuries," and it might be then expected that a larger proportion of our youth would devote themselves to the cultivation of some one or other of the Muses. Were Australia by this action able to stamp her graduates with the broad seal of honor so clearly and indelibly as to be recognised and acknowledged by all, we should not find so many instances of men who have taken their degrees proceeding to England for the purpose of obtaining the *same* degree there.

That there should be a common standard and a common examination for what are known as the higher degrees is equally clear. The doctorate of science, or of laws, or of letters, should not be readily granted or easily obtainable; it would be possible for any one of the three universities to so alter the regulations as to make the doctorate a *pons asinorum*, and we might be almost dazzled by the frequent displays of scarlet and crimson; and as by Her Majesty's charter these degrees pass current through the Empire, such action taken by any university would be a distinct wrong to those whose degrees were conferred by those who held a correct view of the functions and dignity of the doctorate. I do not say that this is likely to be done by any, but it is possible, and so far as it is possible it serves to strengthen my advocacy.

To conclude, as I am a clergyman, may I add a few words by way of practical application? Might not some of those who share my opinions in this matter hold a meeting during this session of this Association, and might not that meeting agree upon some general lines of concordant action? For example, might not representatives of each university undertake to bring the question before the senate of each university, and obtain an expression of opinion? This, if favorable, might be submitted to the council or governing body for their consideration; if so approved by both houses the matter would pass from the purely academic stage into the hands of experts, *i.e.*, to the professors. The professors in any particular school could, I believe, without much difficulty formulate a scheme for common adoption by the universities. The changes which they would make need not be great—certainly would not be revolutionary. There would doubtless be some little displacement and adjustments of subjects, but these, as I have already shown, would most probably be a distinct gain to all.

Some five years ago Professor Morris, with whom I was talking on this question, told me that he had advocated it shortly after his arrival in Australia. I should be sorry to think that so important a question should be indefinitely postponed. If, therefore, I have made good my case, and there be any who are willing to act, might it not be that we should be able to report such progress at the next meeting of this Association as to encourage the hope that the object at which I have been aiming would be within easy reach of attainment?



4.—THE HOME READING UNION.

By Mrs. WOLSTENHOLME.



5.—THE EDUCATION OF AUSTRALIAN GIRLS.

By Mrs. KELSEY.

(ABSTRACT.)

Most women had, by the nature of their sex, to be educators. Dealing first with physical education, the writer said that they must place health first, the laws of which were taught by physiology and hygiene, but they must not forget to insist upon those laws being carried out; else was the teaching useless. Nearly allied to

physical was moral health, and there was no reason why girls should not be taught ethics as well as boys. She strongly protested against the prevalent idea that girls had no use for the higher branches of education, and the arguments often put forward that all that was wanted was that they should carry out household duties. Statistics showed that 20 per cent. of the women of the world did not marry, and it was a rank injustice that they should be cramped within such narrow limits of education on the chance of their getting married. The difficulties of teaching were greater with girls than with boys, for by the nature of their sex they lived more in a groove, and the long use, custom, and necessity which forced women to live chiefly within doors had narrowed their views to a certain extent. With regard to woman's work and position in the present day, there was no doubt that there had been a steady forward movement in all civilised countries in the direction of woman's emancipation. Women were beginning to find "that the hinges of custom were not always the hinges of reason." When that emancipation had come every woman would have her lawful work to do, but during the reaction there would unfortunately be certain to arise that class of women who, having thrown off conventionalism and men's absolute authority, would plunge violently into the opposite extremes, thereby jarring against all that was refined and delicate in true woman. However, given equal training, history itself proved that women were quite as capable of work as men were. The emancipation of women would have to be founded on economic principles. If every woman, no matter what her rank, were trained to some business or profession by which she could sustain herself if necessary the days would soon be over when girls would look forward to marriage as the great aim and object of their existence, or, as was so often the case, as a means of livelihood.

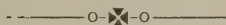
The granting of suffrage to women was only a matter of time, and they would have to make the strongest point of educating their girls in a manner to fit them to influence for good those who would fight out those fights and reap the benefit of the present struggle towards the emancipation of woman. The plan of co-education of girls and boys had been adopted in America, and had answered well; it seemed to be a natural system, and therefore a good one. The special difficulties in the training of Australian girls were that they showed a want of reverence and veneration, a certain defiance of authority, and a growing tendency to criticise the methods and skill of their teachers. The present age also demanded quick results in education instead of that "infinite capacity for taking pains" and that "humiliating exactness," without which no really great work had ever been achieved. The extraordinary accent which distinguished the speech of young Australians threatened to become as objectionable as that of the Americans, and great effort should be made by teachers to make

their pupils speak pure English. As to the good points in the national character of the girls, there was undoubtedly a splendid capability, courage, and energy about them which in many cases developed into a domestic genius. This made Australian women independent to a great extent of hired help. They were essentially sympathetic, and possessed tact and grace, and were comparatively free from that self-consciousness and affectation from which girls suffered who were brought up in a more confined and less free atmosphere. The energy of the Australian girls, the love of pleasure, and a desire for "something new" were some of their strong characteristics. There was also a strong lack of concentrative force, which alone could lead to the acquirement of knowledge and high culture. The education of the emotions was a most important point.



6.—THE VALUE OF TECHNICAL EDUCATION TO ARTISANS IN THE BUILDING TRADE.

By HILLSON BEASLEY.



7.—A PLEA FOR PRACTICAL EDUCATION.

By W. CATTON GRASBY.



8.—DEAF MUTE EDUCATION.

By G. WATSON.



9.—OCULAR EDUCATION IN PUBLIC ELEMENTARY SCHOOLS, AND ITS BEARING ON SOCIETY.

By A. E. MUELLER.

10.—SOME METHODS OF EDUCATION AS PRACTISED
IN THE PRIMARY PUBLIC SCHOOLS OF SOUTH
AUSTRALIA.

By M. M. MAUGHAN.



11.—SOME PREDILECTIONS OF PICTORIAL AND
DECORATIVE ART.

By H. P. GILL.

(WITHDRAWN.)



12.—NOTES OF PSYCHOPHYSICAL EXPERIMENTS.

By E. F. J. LOVE, M.A., *Fellow and Rector of Queen's College, Melbourne, Assistant Lecturer and Demonstrator in Natural Philosophy to the University.*

The object of this paper is to detail the results, so far as they are of interest from the psychological point of view, of certain experiments originally carried out with a quite different object.

1st. The determination of the limit of comparability in the illumination of two bright surfaces viewed simultaneously.

Several methods were employed. In the first a circular disc of opal glass was rotated at a very high speed by means of an electro-motor. A narrow radial black mark, about an inch long, being made by one observer on some part of the disc, it was set in rotation; and the second observer, previously outside the laboratory, was called in and requested to state whether the disc showed a grey ring, and, if so, to define its position by reference to a foot rule placed opposite the disc. The narrowest line which gave a perceptible grey ring had a breadth of about $1/180$ th part of the circumference of the ring; hence the smallest difference of intensity perceived in this way was the $1/180$ th part of the intensity of the light diffused from the opal glass. The experiment was conducted in full daylight.

Other experiments, conducted with artificial light, using ordinary photometric methods, gave a lower value, about 1 per cent. being the smallest perceptible difference. It was found that with colored lights even this was considerably reduced. Furthermore, the results depended considerably on the intensity of the light em-

ployed, even moderately bright or faint light giving bad results, while lights of about 1-2 candlepower could be compared with the smallest margin of error. Shielding the eyes from extraneous light was found to be necessary, as it is difficult to ensure a sufficient fixity of attention.

The bearing of these results on Weber's law is obvious. According to them, the proportionality between the increment of sensation and the percentage increase of stimulus only holds a very limited range, the constant of proportionality being quite different for bright lights and those of moderate intensity, while for lights of extreme brightness it seems likely that all difference of sensation is lost.

2nd. The rate at which visual impressions must succeed each other in order to be fused.

This experiment was tried in conjunction with Professor Haycraft, of Mason College, Birmingham, who devised the method and constructed the apparatus. A large pendulum in the form of a segment of a circle was employed, and adjustable slits could be placed at any desired position along the arc. The observer was stationed in a darkened enclosure behind the pendulum, which could be viewed through an aperture in the side of the enclosure; hence no light could enter the enclosure save when a slit was passing the aperture. The slits were adjusted by a second experimenter. The largest time interval which allowed of the fusion of the impressions was found in this way for a single observer to be about $1/22$ nd of a second for white light and $1/18$ th for red. The difference between the two was well marked, for the same placing of the slits which allowed the impressions from the red light to be fused left those from the white light distinct, though the slits had only to be displaced through a very small distance in order to fuse the impressions from the white light.

In both sets of observations recorded in this paper blank experiments were intercalated, in order to guard against possible bias on the part of the observer, who of course was kept in ignorance of the actual condition of the apparatus, except in so far as the observations themselves disclosed it.



13.—SIMPLIFICATION OF DIFFICULTIES IN CONNECTING THE TONIC SOL-FA AND THE OLD NOTATION.

By W. A. JONES.

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